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MATHEMATICS

ON THE ADJOINT TRANSFORMATION

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I. Let $\{x_n\}$ be a determining sequence of a closed linear symmetric transformation $g = Hf$ defined in the manifold D of Hilbert complex space $\mathfrak{H}$. Then $f = \sum_{i=1}^{\infty} c_i x_i$ and $g = \sum_{i=1}^{\infty} c_i y_i$, where $y_i = Hx_i$ $(i = 1, 2, \ldots)$ and $\{c_i\}$ are all the possible sequences satisfying the condition $\sum_{i=1}^{\infty} |c_i|^2$ (1).

If the components of x_n and y_n with regard to a certain complete orthonormal system $\{\varphi_i\}$ are represented by a_k^n and b_k^n respectively, it is evident that $x_n = \sum_{k=1}^{\infty} a_k^n \varphi_k$ and $y_n = \sum_{k=1}^{\infty} b_k^n \varphi_k$. A question suggests itself: could a complete orthonormal system be chosen in such a way that two sequences of the elements

$$x_n' = \sum_{k=1}^{\infty}{}' \bar{a}_n^k \varphi_k \quad \text{and} \quad y_n' = \sum_{k=1}^{\infty}{}' \bar{b}_n^k \varphi_k \quad (n = 1, 2, \ldots) \tag{1}$$

would determine the transformation H^*, adjoint with the transformation H, just the same as two systems of elements $\{x_n\}$ and $\{y_n = Hx_n\}$ determine the transformation H? The present work gives an answer to this question on the assumption that H is the maximal transformation.

The following theorems are to be proved first, without making any special assumption neither for the transformation H nor for the system $\{\varphi_i\}$:

Theorem 1. The sequences $\sum_{k=1}^{n} c_k' x_k'$ and $\sum_{k=1}^{n} c_k' y_k'$ converge weakly to the elements:

$$\left.\begin{aligned} f' &= \sum_{k=1}^{\infty} (c_1'\bar{a}_1^k + c_2'\bar{a}_2^k + \ldots + c_n'\bar{a}_n^k + \ldots)\varphi_k \\ \text{and} \qquad g' &= \sum_{k=1}^{\infty} (c_1'\bar{b}_1^k + c_2'\bar{b}_2^k + \ldots + c_n'\bar{b}_n^k + \ldots)\varphi_k \end{aligned}\right\} \tag{2}$$

if $m \to \infty$ whatever may be the sequence $\{c'_n\}$ satisfying the condition $\sum_{n=1}^{\infty} |c'_n|^2 < \infty$.

In order to prove this, the convergence of the series $\sum_{k=1}^{\infty} |a_n^k|^2$ and $\sum_{k=1}^{\infty} |b_n^k|^2$, the convergence of the series $\sum_{i=1}^{\infty} \left| \sum_{k=1}^{\infty} c_k a_i^k \right|^2$ and $\sum_{i=1}^{\infty} \left| \sum_{k=1}^{\infty} c_k b_i^k \right|^2$ for all sequences $\{c_i\}$ for which $\sum_{i=1}^{\infty} |c_i|^2 < \infty$, and, finally, the convergence of the series $\sum_{i=1}^{\infty} c'_i \sum_{k=1}^{\infty} c_k a_i^k$ and $\sum_{i=1}^{\infty} c'_i \sum_{k=1}^{\infty} c_k b_i^k$ should be taken into account.

Corollary. The series $\sum_{k=1}^{\infty} \left| \sum_{i=1}^{\infty} c_i \bar{a}_i^k \right|^2$ and $\sum_{k=1}^{\infty} \left| \sum_{i=1}^{\infty} c_i \bar{b}_i^k \right|^2$ are convergent for all sequences $\{c_i\}$ satisfying the condition $\sum_{i=1}^{\infty} |c_i|^2 < \infty$.

Let D' be the manifold of all elements f' represented by a «sum» of a weakly convergent series $\sum_{n=1}^{\infty} c'_n x'_n$ provided that $\sum_{n=1}^{\infty} |c'_n|^2 < \infty$.

Theorem 2. Each element $f' \in D$ may be presented in the form of a «sum» of a weakly convergent series $\sum_{1}^{\infty} c'_n x'_n \left(\text{where } \sum_{n=1}^{\infty} |c'_n|^2 < \infty \right)$ uniquely. The manifold D is a linear manifold everywhere dense in $\mathfrak{H}$.

In order to prove the first part, it must be taken into account that, if element F of the space $\mathfrak{H}$ is orthogonal to all elements of the determining sequence, then $F = \theta$ (zero element). To demonstrate the second part, it is necessary to take into account the uniqueness of representation of the element $f \in D$ (D is the domain of transformation H) in the form of $f = \sum_{i=1}^{\infty} c_i x_i$ where $\sum_{i=1}^{\infty} |c_i|^2 < \infty$.

From the above proofs it is seen that to each element $f' \in D'$ corresponds one and only one element g'; if $f' = \text{weak} \lim_{n \to \infty} \sum_{i=1}^{n} c'_i x'_i$ then $g' = \text{weak} \lim_{n \to \infty} \sum_{i=1}^{n} c'_i y'_i$ (the sequence $\{c'_i\}$ for f' is the same as for g'). We will say that the sequences $\{x'_n\}$ and $\{y'_n\}$ determine the transformation

$$g' = H' f' \qquad (3)$$

($y'_n = H' x'_n$).

D' is the domain of transformation H'.

II. Theorem 3. Let $g = Hf$ be a maximal linear symmetric transformation defined in the domain D; let, further, $x_1, x_2, \ldots, x_n \ldots$ be its determining sequence and $y_n = Hx_n$ ($n = 1, 2, \ldots$). Then there exists in $\mathfrak{H}$ such a complete orthonormal system $\{\varphi_i\}$ that transformation $g' = H' f'$,

determined by the sequences $\{x'_n\}$ and $\{y'_n\}$, where $x'_n = \sum_{k=1}^{\infty} \overline{a}_n^k \varphi_k$; $y'_n = \sum_{k=1}^{\infty} \overline{b}_n^k \varphi_n$, and $a_n^k = (x_k, \varphi_n)$, $b_n^k = (y_k, \varphi_n)$, coincides with the transformation H^* (H^* adjoint with H), i. e. $H' \equiv H^*$. Each element f^* of the domain D^* can de represented, uniquely, in the form of a sum of a weakly convergent series

$$f^* = \text{weak} \lim_{n\to\infty} \sum_{k=1}^{n} c'_k x'_k \text{ where } \sum_{n=1}^{\infty} \left|c'_n\right|^2 < \infty \text{ and, inversely, if } \sum_{n=1}^{\infty} \left|c'_n\right|^2 < \infty$$

the series $\sum_{n=1}^{\infty} c'_n x'_n$ weakly converges and the element determined by it belongs to D^*.

Proof. We shall introduce the following notation:

$$\theta_n = y_n + ix_n \tag{4}$$

and

$$\psi_n = y_n - ix_n. \tag{5}$$

As $\{x_n\}$ is the determining sequence and $y_n = Hx_n$, it follows that the sequences $\{\theta_n\}$ and $\{\psi_n\}$ are orthonormal sequences. We obtain from (4):

$$y_n = \frac{\theta_n + \psi_n}{2} \text{ and } x_n = \frac{\theta_n - \psi_n}{2i}. \tag{6}$$

We shall suppose, for certitude, that the maximal transformation $g = Hf$ has a deficiency index of the form $(n, 0)$ $(n = 1, 2, \ldots, \aleph_0]$. Then $\{\psi_n\}$ [see (4)] is a complete orthonormal system. We shall demonstrate that the system $\{\psi_n\}$ quite satisfies the conditions of the theorem.

Let us introduce the notation

$$\alpha_m^n = (\theta_n, \psi_m) \quad (n, m = 0, 1, 2, \ldots). \tag{7}$$

Thus $\theta_n = \sum_{k=1}^{\infty} \alpha_k^n \psi_k$ and, therefore:

$$\sum_{k=1}^{\infty} \alpha_k^n \overline{\alpha}_k^m = 0 \quad (n \neq m); \quad \sum_{k=1}^{\infty} \left|\alpha_k^n\right|^2 = 1 \text{ and } \sum_{n=1}^{\infty} \left|\alpha_k^n\right|^2 \leqslant 1 \tag{8}$$

[the inequality in the third one of the relations (8) is explained by the fact that the system $\{\theta_n\}$ may be incomplete].

Further, on account of (6) we obtain:

$$a_n^m = \frac{\alpha_n^m}{2i} \ (n \neq m) \text{ and } a_n^n = \frac{\alpha_n^n - 1}{2i},$$

$$b_n^m = \frac{\alpha_n^m}{2} \ (n \neq m) \text{ and } b_n^n = \frac{\alpha_n^n + 1}{2};$$

whence

$$x_n = \frac{1}{2i}[\alpha_1^n \psi_1 + \alpha_2^n \psi_2 + \ldots + (\alpha_n^n - 1)\psi_n + \ldots], \tag{9}$$

$$y_n = \frac{1}{2}[\alpha_1^n \psi_1 + \alpha_2^n \psi_2 + \ldots + (\alpha_n^n + 1)\psi_n + \ldots], \tag{9'}$$

and respectively:

$$x'_n = \frac{-1}{2i}\left[\bar{\alpha}^1_n\psi_1 + \bar{\alpha}^2_n\psi_2 + \ldots + (\bar{\alpha}^n_n - 1)\,\psi_n + \ldots\right], \tag{10}$$

$$y'_n = \frac{1}{2}\left[\bar{\alpha}^1_n\psi_1 + \bar{\alpha}^2_n\psi_2 + \ldots + (\bar{\alpha}^n_n + 1)\,\psi_n + \ldots\right]. \tag{10'}$$

Using the relations (9) and (10), we prove that the following relation takes place:

$$(y_n,\ x'_m) = (x_n,\ y'_m). \tag{11}$$

Further, as, firstly, $f = \sum_{n=1}^{\infty} c_n x_n$; $g = Hf = \sum_{n=1}^{\infty} c_n y_n$, and, secondly, $f' = \text{weak}\lim_{n\to\infty} \sum_{k=1}^{n} c'_k x'_k$; $g' = H'f' = \text{weak}\lim_{n\to\infty} \sum_{k=1}^{n} c'_k y'_k$, then, taking into account (11) we obtain at once:

$$(Hf,\ f') = (f,\ H'f'). \tag{12}$$

From the above it is seen that the transformation H' is a part of the transformation H^*. Now we shall demonstrate inversely that $D^* \subset D'$. Each element $f' \in D'$ may be presented in the form (Theorem 1):

$$f' = \frac{-1}{2i}\sum_{n=1}^{\infty}\left[c'_1\bar{\alpha}^n_1 + c'_2\bar{\alpha}^n_2 + \ldots + c'_n(\bar{\alpha}^n_n - 1) + \ldots\right]\psi_n, \tag{13}$$

and it is to be proved that each element $f^* \in D^*$ may be presented in the form (13). But, as is well known (2), each element $f^* \in D^*$ may be presented in the form:

$$f^* = f + g \tag{14}$$

where $f \in D$ (D is the domain of transformation H) and g is the element orthogonal to all $\theta_n (n = 1, 2, \ldots)$. Thus, it will be sufficient to demonstrate that each element $f \in D$ may be presented in the form (13) and that in the same form also may be presented every element g orthogonal to all θ_n. Let be $f \in D$, then $f = \sum_{k=1}^{\infty} c_k x_k$ or, what is the same ,

$$f = \frac{1}{2i}\sum_{n=1}^{\infty}\left(c_1\alpha^1_n + c_2\alpha^2_n + \ldots + c_n(\alpha^n_n - 1) + \ldots\right]\varphi_n. \tag{15}$$

Comparing (15) with (13) we conclude that every element may in that only case be presented in the form (13) when the system of equations:

$$\begin{aligned}\bar{\alpha}^n_1 c'_1 + \bar{\alpha}^n_2 c'_2 + \ldots + (\bar{\alpha}^n_n - 1)\,c'_n + \ldots &= \\ = -\left[c_1\alpha^1_n + c_2\alpha^2_n + \ldots + c_n(\bar{\alpha}^n_n - 1) + \ldots\right]&\end{aligned} \tag{16}$$

$(n = 1, 2, \ldots)$ has a solution $\{c'_i\}$ satisfying the condition $\sum_{i=1}^{\infty}|c'_i|^2 < \infty$ whatever may be the sequence of numbers $\{c_i\}$ for which $\sum_{i=1}^{\infty}|c_i|^2 < \infty$.

In order to abbreviate the writing we shall introduce the notation:

$$\sum_{i=1}^{\infty}{}' c_i a_n^i = c_1 a_n^1 + c_2 a_n^2 + \ldots + c_n (a_n^n - 1) + \ldots$$

and

$$\sum_{i=1}^{\infty}{}' \bar{a}_i^n c_i' = \bar{a}_1^n c_1' + \bar{a}_2^n c_2' + \ldots + (\bar{a}_n^n - 1) c_n' + \ldots$$

The system (16) has a solution (3) provided that the inequality:

$$\Big| \sum_{i=1}^{n} \mu_i \sum_{k=1}^{\infty}{}' c_k a_i^k \Big|^2 \leqslant M \sum_{k=1}^{\infty} \Big| \sum_{i=1}^{n}{}' \bar{a}_k^i \mu_i \Big|^2$$

is true for a certain $M > 0$, for arbitrary positive integer n and for arbitrary complex numbers $\mu_1, \mu_2, \ldots, \mu_n$. Hence it is a fortiori the case if the inequality:

$$\Big| \sum_{i=1}^{\infty} \mu_i \sum_{k=1}^{\infty}{}' c_k a_i^k \Big|^2 \leqslant M \sum_{k=1}^{\infty} \Big| \sum_{i=1}^{\infty}{}' \bar{a}_k^i \mu_i \Big|^2, \tag{17}$$

is true for every sequence $\{\mu_i\}$ for which $\sum_{i=1}^{\infty} |\mu_i|^2 < \infty$. But the inequality (17) is true if we put in it $M = \sum_{i=1}^{\infty} |c_i|^2$. To prove this assumption et must be taken into account that all the series in (17) are absolutely converging and from the relations (8) follow the relations:

$$\sum_{k=1}^{\infty} \Big| \sum_{i=1}^{\infty} \mu_i a_k^i \Big|^2 = \sum_{i=1}^{\infty} |\mu_i|^2 \text{ and } \sum_{k=1}^{\infty} \Big| \sum_{i=1}^{\infty} \mu_i a_i^k \Big|^2 \leqslant \sum_{i=1}^{\infty} |\mu_i|^2$$

(all the sums without the sign $'$), and from the latter, after a short computation, the following relation is obtained:

$$\sum_{k=1}^{\infty} \Big| \sum_{i=1}^{\infty}{}' \mu_i a_i^k \Big|^2 \leqslant \sum_{k=1}^{\infty} \Big| \sum_{i=1}^{\infty}{}' \mu_i \bar{a}_k^i \Big|^2,$$

from which we are getting (17), changing in the right part of (17) the order of summation and applying Swartz's inequality.

It remains now to demonstrate that, if $(g, \theta_n) = 0$ $(n = 1, 2, \ldots)$, g may be presented in the form (13). Let be

$$g = \gamma_1 \psi_1 + \gamma_2 \psi_2 + \ldots + \gamma_n \psi_n + \ldots;$$

then

$$(g, \theta_n) = \gamma_1 \bar{a}_1^n + \gamma_2 \bar{a}_2^n + \ldots + \gamma_n \bar{a}_n^n + \ldots = 0;$$

whence

$$\gamma_n = -\gamma_1 \bar{a}_1^n - \gamma_2 \bar{a}_2^n - \ldots - \gamma_n (\bar{a}_n^n - 1) - \ldots =$$
$$= c_1' \bar{a}_1^n + c_2' \bar{a}_2^n + \ldots + c_n' (\bar{a}_n^n - 1) + \ldots$$

where $c'_k = 2i\gamma'_k$ and, consequently, $\sum_{k=1}^{\infty}{}' \left|c'_k\right|^2 < \infty$, whereby the assumption is proved.

In accordance with the Theorems 1 and 2 each element of the domain D^* may be, in the unique manner, presented in the form of weak $\lim \sum_{i=1}^{n}{}' c'_i x'_i$ where $\sum_{i=1}^{\infty}{}' \left|c'_i\right|^2 < \infty$ and, inversely, if $\sum_{i=1}^{\infty}{}' \left|c'_i\right|^2 < \infty$ then the series $\sum_{i=1}^{\infty} c'_i x_i$ is w e a k l y convergent and the element determined by it belongs to the domain D^*, thus Theorem 3 is proved.

Let the sequence $\{x'_n\}$ [given by the formulae (10)] be called the determining sequence of the transformation H^* adjoint with the determining sequence $\{x_n\}$ of the transformation H [given by the formulae (9)].

Retaining the former notation and continuing to suppose, for certainty, that the deficiency index of the maximal transformation H has the form $(n, 0)$, the following proposition may be easily proved.

T h e o r e m 4. 1) Let be $f' \in D^*$, i. e. $f' = \text{weak } \lim \sum_{k=1}^{n} c'_k x'_k$, then the numbers $\{c'_k\}$ represent Fourier's coefficients of the element $g' + if'$ where $g' = H^* f' = \underset{n\to\infty}{\text{weak } \lim} \sum_{k=1}^{n}{}' c'_k y'_k$ with regard to the complete orthonormal system $\{\psi_n\}$ (in particular $y'_n + ix'_n = \psi_n$) and thus $\sum_{n=1}^{\infty}{}' \left|c'_n\right|^2$ does not depend upon the choice of the determining system $\{x'_n\}$. 2) If H is an self-adjoint transformation, then the elements $\vartheta_n = y'_n - ix'_n$ also form a complete orthonormal system; the series $\sum_{i=1}^{\infty}{}' c'_i x'_i$ and $\sum_{i=1}^{\infty}{}' c'_i y'_i$ converge strongly and the sequence $\{x'_n\}$ is the determining sequence of the transformation H.

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PHYSICS

ON THE LIMITING FORM OF THE FREE CONVECTION LAW FOR HIGH VALUES OF GRASSHOF'S CRITERION

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A well-known consequence of the theory of similarity is that the law of heat transfer due to free convection must have the form:

$$Nu = \Phi(Gr, Pr), \tag{1}$$

where $Nu = \frac{\alpha d}{\lambda} = \frac{\alpha d}{c\rho x}$ is Nusselt's criterion,

$Gr = \frac{g d^3}{\nu^2} \frac{\Delta\rho}{\rho}$ is Grasshof's criterion,

$Pr = \frac{\nu}{\varkappa}$ is Prandtl's criterion [1, 2].

The value of $\frac{\Delta\rho}{\rho}$ is proportional to the excess of temperature: it is equal to $\beta\Delta T$, where β is the coefficient of expansion; in particular, for an ideal gas $\frac{\Delta\rho}{\rho} = \frac{\Delta T}{T}$. The criterion of similitude of the fields of physical constants, which is implied in all the laws derived from the theory of similarity, will not now be taken into account.

When the values of Grasshof's criterion are low, the influence of convection is absent, and this law tends to the law of heat transfer by conduction: $Nu =$ $=$const. As shown by experiments on the external heat transfer of tubes of varying diameters [3], if the values of Gr are high, there is a region where the coefficient of heat transfer α does not depend on the diameter of the tube, i. e. Nu is proportional to $Gr^{1/3}$. There is a tendency to regard this law as a limiting one for very high values of Gr and to consider the non-dependence of α on the diameter as a kind of automodelity.

The origin of this tendency may be traced up to Boussinesq, who makes the following statement in his work on free convection [4]: «since the intensity of thermal exchange cannot increase with the decrease of the curvature of the surface, the coefficient of heat transfer cannot increase with the increase of the determining dimension». It is obvious that considerations of this kind carry no conviction.

In reality, things are different. An automodel region may occur only when the values of Gr are so high as to render the motion an entirely turbulent one. Now, in perfectly turbulent motion, the macroscopic picture of molar transfer is known to become independent of the coefficients of molecular exchange [5], which would entirely eliminate from the equations the coef-

ficients of molecular viscosity and temperature conductivity. Under an inertial regime, the criteria Gr and Pr enter into equation (1) as the combination $GrPr^2 = \frac{gd^3}{\varkappa^2}\frac{\Delta\rho}{\rho}$; since this value involves temperature conductivity to the second power and Nu to the first, the limiting form of the law of heat transfer with high Gr's should be:

$$Nu = kGr^{1/2}\,Pr. \qquad (2)$$

The fact that the transmission of heat in the boundary layer inevitably occurs by way of molecular thermal conductivity is not at all contradictory with the above considerations. It is important in principle, since, with a thermal conductivity equal to zero, no heat transfer would be possible; as, however, thermal conductivity differs from zero, a temperature gradient automatically established in the boundary layer corresponds to the amount of heat brought to the border of the boundary layer by turbulent transfer.

The equation of hydrodynamics for the case of stationary free convection would, if $g\rho_0$ were substituted for grad p, give two criteria $\frac{vd}{\nu} = Re$ and $\frac{gd^2}{v\nu}\frac{\Delta\rho}{\rho}$. Neither is a determining one since both involve velocity, which is not among the conditions of uniformity, but we may, by combining them, obtain a determining criterion that would not involve velocity and would be equal to the product of both:

$$\frac{gd^3}{\nu^2}\frac{\Delta\rho}{\rho} = Gr.$$

The equation of thermal conductivity gives the Pe criterion which is equal to $Re\,Pr$, i. e. differs form Re only by a constant factor for any given substance.

With high values of Gr, the viscosity member of hydrodynamics equation may be neglected; the equation will then have the form (v grad) $v = g\frac{\Delta\rho}{\rho}$ and will give one criterion $\frac{gd}{v^2}\frac{\Delta\rho}{\rho}$. We thus obtain in effect an automodel region. Everywhere except in the boundary layer, the thermal conductivity equation will be converted into (v grad) $T=0$, and will yield no criterion at all. (All the equations are written in actual values.) The average velocity of motion, as well as the mean quadratic value of pulsation velocity, are proportional to $\sqrt{gd\frac{\Delta\rho}{\rho}}$, while the coefficient of heat transfer is proportional to $c\rho v$, i. e. $c\rho\left(gd\frac{\Delta\rho}{\rho}\right)^{1/2}$, which is identical with equation (2).

From the law evolved it follows that, with high values of Grasshof's criterion, the coefficient of heat transfer must increase with the increase of the dimensions of the body in direct ratio to the square root of the determining dimension. The flow of heat must be proportional to the excess of temperature to the $^3/_2$ power. Finally, for gases, the coefficient of heat transfer must be proportional to pressure (by analogy with Knudsen's region). In applying the latter conclusion to the cooling of a hot gas placed inside a vessel with cold walls we find that the characteristic time of heat transfer must not, in the limiting case under consideration, be dependent on pressure. There is of course no reason to confine the applicability of our considerations to the cooling of a body in infinite space; it is true that, in the form under consideration, they are, strictly speaking, applicable only to stationary or quasi-stationary cooling; it is, however, easy to show that the dependences of the time of cooling, found for the quasi-stationary case, are also maintained

for the non-stationary case, as is usual for such relations as are obtained from dimensional considerations.

The law found is a limiting one. It is, of course, impossible to state a priori whether the conditions in which it might be observed can be realized experimentally. In any case, there is no doubt whatever that the $Nu = k\ Gr^{1/3}$ law is not a limiting one and does not correspond to any automodel region; that, in increasing Gr, it is always theoretically possible to reach a region where the coefficient of heat transfer grows with the increase of the dimensions of the body, and that any analytical expression of the free convection law claiming the possibility of unlimited extrapolation must, with $Gr \to \infty$, give $Nu = k\ Gr^{1/2}\ Pr$ at the limit.

According to the geometrical configuration of the system and the value of Pr, the second automodel region may begin at various values of Gr. Thus, for the external problem, i. e. for the cooling of a body in infinite space, it may hardly be reached in the same way as in the internal problem of forced convection, even with very high values of Re, one does not, however, succeed in noticing any approach to the second automodel region. On the contrary, with such configurations of the system as favour the development of a turbulence due to the convection itself, an early occurrence of the second automodel region may be expected. This, for example, refers to cases where the convection motion is necessarily a disorderly one, for instance, to the cooling upwards of an infinite horizontal plate, or, more exactly, to a stationary flow of heat between two infinite horizontal plates, whereof the lower one has a higher temperature than the higher one.

The increase of the coefficient of heat transfer with size has a very simple physical meaning; being due to the fact that lifting power is proportional to the height of the column of hot gas: $\Delta p = gH\Delta\rho$. The possibility of such a phenomenon is quite obvious for systems of a limited volume; American authors are inclined to discriminate between this phenomenon and convection, and to term the former «draught effect» ([6]); such a discrimination is, of course, quite arbitrary. Some authors are of the opinion that free convection ought to mean only the cooling of a body in infinite space. In reality, however, the geometrical configuration of the system affects only the magnitude of the numerical coefficients in the equations containig the criteria, and also the form of analytical dependence in the transition region, but does not in any way affect either the form or the number of the criteria themselves, or the existence of any automodel regions. The latter conditions are solely determined by the form of the equations themselves and that of the conditions of uniformity. Free convection should be understood to mean any process of heat transfer where the conditions of uniformity do not involve velocity, no matter whether it takes place in a limited or in infinite space. If a second automodel region exist for processes taking place in limited space, it must also exist for the cooling of a body in infinite space, the more so as a continuous transition from one case to another is possible. In fact, in the case of cooling in infinite space, in an automodel region (leaving aside the question of the possibility of reaching it), the average height of the column of hot gases over the cooling body must be proportional to the determining dimension of the body; which would result, as in the case of limited volume, to the occurrence of the «draught effect» and of the $Nu = kGr^{1/2}$ law. Of course, in order that the increase of the coefficient of heat transfer with the dimensions of the cooling body might be detectable experimentally, the systems to be compared ought really to be geometrically similar, i. e. the space where the circulation of hot gases takes place should be sufficiently large, as compared with the region of disturbance due to the hot body, or should increase in direct ratio to the dimensions of the latter. If not, the determining dimension may

be, e. g., the height of the room where the experiment is being carried out.

Let us examine a simple example showing the validity of the limiting law evolved. A heated vertical tube of height H and diameter d is being cooled in infinite space. The outer surface of the tube is coated with a heat insulating material, so that cooling takes place only on the inner surface. The difference of pressures outside and inside the tube is $g\,H\Delta\rho$. If Gr are great (H and ΔT are high, the viscosity of the gas is low), the flow will follow the quadratic law, at a velocity of $\sqrt{\frac{2g}{\zeta}\,d\,\frac{\Delta\rho}{\rho}}$ where ζ may be considered constant at the limit, the temperature of the gas issuing from the upper end of the tube being equal to that of the walls, so that the coefficient of heat transfer will be:

$$\alpha = c\rho\sqrt{\frac{gd^3}{8\zeta H^2}\,\frac{\Delta\rho}{\rho}},$$

and Nusselt's criterion:

$$Nu = \frac{\alpha d}{c\rho\varkappa} = \sqrt{\frac{gd^3}{8\zeta H^2\varkappa^2}\,\frac{\Delta\rho}{\rho}} = \frac{1}{2\sqrt{2}}\,\frac{d}{H}\,Gr^{1/2}\,Pr.$$

The law examined above may be of great importance in the theory of post-explosion heat transfer, and, more particularly, of heat transfer in internal combustion engines, where, owing to the high values of $\frac{\Delta T}{T}$ one has to deal with high values of Gr; the turbulent action of the explosion itself may also accelerate the appearance of the second automodel region. Unfortunately, these phenomena are so complicated through the presence of radiation and, possibly, of forced convection due to the propagation of flame and the motion of the piston, that it is difficult to draw any quantitative conclusions. According to Bone's ([7]) data, the characteristic time of poste-explosion heat transfer changes but little with the change of the initial pressure from 5 to 125 atm. Hence it may be concluded that, if free convection plays a vital part in post-explosion heat transfer, it proceeds under these conditions according to a law approaching the limiting law found above.

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PHYSIQUE

RADIOACTIVITÉ ARTIFICIELLE DE L'ANTIMOINE PROVOQUÉE PAR DES NEUTRONS LENTS

Par K. ALEXEEVA

(Présenté par S. I. Wawilow, de l' Académie, le 10. VII. 1937)

La radioactivité artificielle de l'antimoine provoquée par des neutrons lents a été étudiée en 1934—1935 par Fermi et ses collaborateurs (1). Après que l' antimoine a été bombardé pendant une courte exposition par des neutrons de Rn (350 mC) +Be ralentis dans la paraffine, Fermi et ses collaborateurs ont observé une activité induite à période de 2.5 jours.

J'ai étudié l'activité induite de l'antimoine après un long bombardement par des neutrons lents. Les neutrons étaient obtenus par l'action sur le berillium (600 g) des rayons γ de la source de Ra+MsTh (équivalente à 650 mg du radium par rapport à rayons γ).

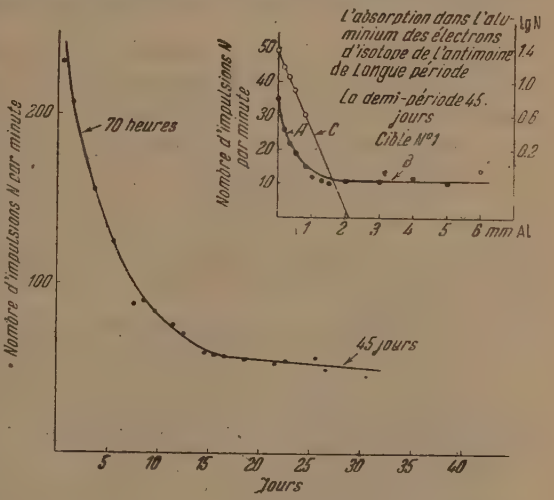

Fig. 1.

Le ralentissement des neutrons était effectué dans la paraffine. L'activité de l'antimoine était mesurée au moyen d'un compteur de Geiger et Müller muni d'une fenêtre constituée d'une feuille de cuivre de 13 μ d'épaisseur. La cible (les dimensions de la cible $50 \times 13.5 \times 8$ mm^3) a été irradiée pendant 42 jours après quoi la courbe de désintégration a été mesurée. On a découvert qu'il y a encore une période égale à 45 ± 5 jours outre celle d'environ 2.5 jours qui a été trouvée par Fermi.

La fig. 1 représente la courbe totale de désintégration du radioantimoine avec ces deux pèriodes. Le rapport entre les activités de la longue et de la courte période (le rapport entre les quantités des atomes désintégrés par unité de temps à la condition de saturation) était égal à 0.3 environ.

La courbe de désintégration d'un isotope à période longue mesurée sur une autre cible et tracée à une échelle demilogarithmique est représentée séparément par la courbe de la fig. 2. Cette cible a été irradiée pendant 22 jours. On a commencé à mesurer la courbe 17 jours après la fin de l'irradiation, c'est-à-dire, quand l'activité de la période courte était pratiquement égale à zero.

Une réaction de la capture d'un neutron lent est bien probable quand on fait irradier des éléments lourds par des neutrons lents. Il en résulte de cette

réaction que nous obtenons un isotope de l'élément irradié. C'est pourquoi on peut attribuer la période de 45 jours ainsi que la période de 70 heures (2.5 jours d'après Fermi) à l'une des réactions:

$$Sb_{51}^{121,123} + n_0^1 \rightarrow Sb_{51}^{122,124}. \quad (1)$$

Livingood (²), qui avait étudié l'activité de l'antimoine irradié par des deutons, a trouvé trois périodes; 24 heures, 2.8 jours (qu'il suppose identique à la période de 2.5 jours, découverte par Fermi) et 50 ± 4 jours. Si l'on fait irradier l'antimoine par des deutons, on peut obtenir les isotopes radioactifs à l'aide des réactions suivantes:

$$Sb_{51}^{121,123} + H_1^2 \rightarrow Sb_{51}^{122,124} + H_1^1 \quad (2)$$

où

$$Sb_{51}^{123} + H_1^2 \rightarrow Sn_{50}^{121} + He_2^4. \quad (3)$$

Les autres types possibles des réactions amènent à la formation des isotopes stables.

Livingood suppose que la période de 24 heures appartient à l'isotope de l'étain Sn_{50}^{121} qui se forme par la réaction (3), puisque cette période est évidemment identique à la période de 28 heures, qu'il a obtenu en bombardant l'étain par des deutons, et qui appartient à une isotope de l'étain (ce qui a été prouvé par l'analyse chimique). Fermi a démontré par l'analyse chimique que la période de 2.5 jours appartient à l'une des isotopes de l'antimoine. C'est pourquoi Livingood attribue l'apparition de cette isotope au moyen d'irradiation par des deutons à l'une des réactions (2).

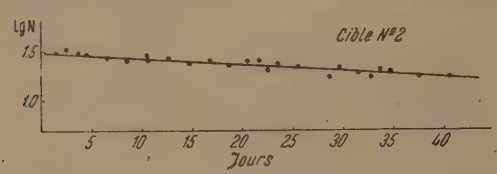

Fig. 2.

D'après Livingood la période de 50 jours s'explique aussi par la formation d'une des isotopes de l'antimoine, Sb_{51}^{122} ou Sb_{51}^{124} d'après la réaction (2).

La période de 45 jours qu'on obtient pour l'antimoine en le bombardant par des neutrons lents est évidemment identique à la période correspondante trouvée par Livingood. Cette conclusion s'accorde avec les déductions de Livingood faites dans son travail cité.

La courbe d'absorption dans l'aluminium des électrons, émis par l'isotope à période longue (la demi-période de 45 jours) est représentée sur la fig. 1. La partie pratiquement horizontale de cette courbe, en commençant par 1.5 mm d'Al, indique probablement la formation du rayonnement γ par la désintégration. Cette courbe a été mesurée en prenant la cible No 1 34 jours après la fin de l'irradiation. La couche d'Al, absorbant les électrons à moitié, est calculée de la partie rapidement descendante A de la courbe d'absorption (sa partie horizontale est soustraite)*. Elle est égale à 0.3 mm d' Al. Livingood (²) donne également la valeur de 0.3 mm d' Al pour l'épaisseur de la couche demiabsorbante, mais sa courbe ne donne aucune indication sur la formation du rayonnement γ par la désintégration.

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* Cette partie de la courbe d'absorption à une échelle demilogarithmique est représentée sur la fig. 1 (la courbe *C*).

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PHYSICS

A NEW METHOD OF IDENTIFYING RADIUM, MESOTHORIUM I AND RADIOTHORIUM IN SEALED PREPARATIONS

By G. V. GORŠKOV and V. N. IONOV

(Communicated by V. I. Vernadsky, Member of the Academy, 10. VIII. 1937)

The most precise method of identifying radium, mesothorium I and radiothorium in concentrated mixed radioactive preparations is admittedly the emanation method, which, however, involves the passage of the preparation into a dissolved condition, and thus gives rise to numerous difficulties.

In 1914, Hahn (1) and then Meyer and Hess (2) suggested a method of determination based on γ-rays and involving the use of an ionizing electroscope. In spite of the improvements in the measurement technique suggested by Bothe (3) in 1924, this method has many important drawbacks, the chief amongst which are:

1) It is impossible to determine independently all the three radioactive elements, unless either the age of the preparation or its content of radium is previously known.

2) It is practically impossible to determine radium, mesothorium I, or radiothorium in mesothorium preparations aged about two years; moreover, no determinations in respect of preparation of about that age can be made with the requisite degree of precision.

In 1933, G. V. Gorškov suggested a method of determining radium, mesothorium I and radiothorium from secondary β-rays. That method, involving the use of a Geiger-Müller counter and based on coincidences, was, however, found on close investigation (4) to have the same main drawbacks as the ionizing methods*.

The discovery of the nuclear photoeffect by Chadwick and Goldhaber (5) in heavy hydrogen, and by Szillard and Chalmers (6) in beryllium makes it possible to suggest a new method for determining radium, mesothorium I and radiothorium in sealed mixed concentrated radioactive preparations, a method free from the drawbacks mentioned above. In addition to this, the new method will probably prove to be extremely simple of execution, since the radioactive preparation is not involved in the measurements.

According to Chadwick and Goldhaber's (5,7) data, the nuclear photoeffect originates in beryllium at a γ-quantum energy greater than $1.6 \cdot 10^6$ eV, and in heavy hydrogen, a γ-quantum energy greater than $2.1 \cdot 10^6$ eV. The energy of the γ-quanta of mesothorium I is known to be (8) below $1 \cdot 10^6$ eV, so that the

* In 1921, M. Cury [C. R. 172, 1022 (1921)] proposed a calorimetric method for determining radium, mesothorium I and radiothorium in mesothorium preparations. This method, however, was not widely adopted owing to the complexity of the measurements.

γ-rays of MsTh I would not produce any nuclear photoeffect in either beryllium or heavy water. The energy of the strongest γ-ray groups of Ra is not sufficient to produce a nuclear photoeffect in heavy hydrogen, but is sufficient to produce such an effect in beryllium.

Practically, therefore, it is only the γ-rays of radiothorium* that can produce a nuclear photoeffect in heavy hydrogen.

According to theoretical data ([9],[7]) the effective cross-section σ for the splitting-up of nuclei by γ-rays is a function of the energy of γ-rays. For beryllium, the values of σ attain $5.3 \cdot 10^{-28}$ cm^2 for γ-rays of an energy of $1.78 \cdot 10^6$ eV (radium γ-rays), and $1.1 \cdot 10^{-28}$ cm^2 for γ-rays having an energy of $2.62 \cdot 10^6$ eV (radiothorium γ-rays).

In heavy hydrogen the value of σ is about $8 \cdot 10^{-28}$ cm^2 for γ-rays of an energy of $2.62 \cdot 10^6$ eV. The experimental data ([7],[10]) are not at variance with the theoretical ones.

The nuclear photoeffect is accompanied by an emission of neutrons. If paraffin, or any other substance rich in hydrogen (e. g. water), is used to produce a slowing down, these neutrons can be easily discovered by some indicators (rhodium, manganese, dysprosium, etc.).

The method of determining radium, mesothorium I and radiothorium in sealed preparations is as follows: upon irradiation of the indicator, in the conditions of the experiment in question, by the slow neutrons produced by the nuclear photoeffect of the γ-rays of the Ra in beryllium and slowed down by paraffin, the number of deflections A of the Geiger-Müller counter in unit time per milligram of radium is determined.

Then, the conditions of the experiment remaining the same except that radiothorium is used instead of radium, the number of deflections αA is determined per milligram of radiothorium, where α is less than unit. The value of α will be determined by the cross-section σ effective for the nuclear photoeffect and by the conditions of the experiment.

Lastly, the number of deflections B is determined in unit time per milligram of RdTh in heavy water. After these preliminary experiments the experimental set-up may be used to determine the content of radium, mesothorium I or radiothorium in any mixed preparation, by determining the number of deflections in the counter upon irradiation in beryllium and in heavy water, and having ascertained the equivalent of R in the preparation by the ionizing method.

Let us indeed assume that, upon irraditation by a mixed preparation in heavy water, the target shows C deflections in unit time. By dividing that value by B we obtain the amount of RdTh in the mixture: $x = \frac{C}{B}$. Let us further assume that, upon irradiation with the mixed preparation in beryllium, the target shows D deflections in unit time. The amount of radium in the mixture y will then be determined by the formula:

$$y = \frac{D - \alpha A x}{A}.$$

Lastly, the amount z of MsTh I is determined by the formula:

$$z = R - x - y.$$

This method thus makes it possible to determine unconditionally the

* According to Chadwick and Goldhaber's ([7]) data, the action of Ra γ-rays is 27 times less.

three radioelements in a mixture* the precision of the determinations being but slightly affected by the age of the preparation.

In order to check the new method experimentally, we made a set-up including a Geiger-Müller counter. High tension was supplied from a rectifier through a Medicus ([11]) stabilizer; the Geiger-Müller counter was a duraluminium tube, 1 cm in diameter, 5 cm long and 0.12 mm thick. During the measurements, the counter was encased in cast-iron armour 10 cm thick. The natural number of deflections of the counter, when placed inside the cast-iron armour, was on an average about 7 per minute.

To record the impulses, a mechanical numerator had been connected with a three-cascade amplifier. A manganese target, 3.4×3.6 cm and about 9.2 cm thick**, was used as indicator of slow neutrons. 8 g of manganese was placed in a celluloid frame, the walls of which were made of celluloid plates 0.2 mm thick. To prevent the displacement of the manganese powder within the frame during manipulaton, one of the walls of the frame was covered with glue, and the manganese powder was spread on it.

During irradiation, the radioactive preparation was placed in a brass capsule, with walls about 2 mm thick, which was in turn placed inside a tin cylinder with walls 0.2 mm thick***. The cylinder was surrounded with a layer of powdered beryllium 23 mm thick and 70 mm high.

The total weight of beryllium was 217 g. The beryllium was placed in a paraffin tank, 257 mm in diameter and 200 mm high, the beryllium cylinder being thus surrounded with a layer of paraffin about 10 cm thick. During exposure, the manganese target was always at the same point, placed between beryllium and paraffin.

During exposure, no other preparations were in the vicinity except the radioactive preparation under test.

The measurement of the activation of the irradiated target always began 30 minutes upon exposure. The exposure usually lasted 12.5 hours.

During bombardement with α-rays, glass becomes a source of neutrons. To surround the radioactive substance in radioactive preparations with an iron cylinder, as this was done by Rusinov and Sagaidak ([10]), is, of course, very difficult and in some cases hardly desirable. We, therefore, measured first of all the effect of neutron emission from an ampoule containing highly concentrated radium, and found it to be, in our experiments, less than 0.02 deflections in one minute per milligram of radium, and therefore beyond experimental error. We used in our experiments a radium preparation containing 28.6 mg of radium metal, and found the irradiated target to give about 4.5 deflections in one minute per milligram, 35 minutes upon exposure.

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* To simplify the scheme, we have in the above left out of account the generation of neutrons in the heavy water under the action of γ-rays of radium. This, however, does not alter essentially our considerations, since we have obtained three equations with three unknown quantities, which can easily be solved.

** Manganese had been selected as indicator of slow neutrons only because we happened to have a sufficient amount of it at our disposal. A much more suitable indicator is dysprosium, which, used in sufficient quantities, would have given (as shown by I. I. Gurevič and M. G. Meščerjakov) six times as many deflections as manganese; as it happened, however, we had not at our disposal a sufficient amount of dysprosium. We might, of course, have used as indicator either rhodium or iridium, the former of which, to judge by Amaldi and Fermi's data ([12]), would have given about 9, and the latter about 2.5 times the number of deflections obtainable with manganese. Rhodium, however, has too small, and indium too great a period of halfdecay, neither of them thus being suitable for preliminary experiments.

*** In making precise measurements, a lead ampoule 5 mm thick should be used as in comparing mesathorium I and radiothorium preparations with those of radium by the ionizing method, a lead filter 5 mm thick is generally employed. If we used a brass capsule it was simply because we had one at hand, and also because the thickness of the filter is but of slight importance in our experiments on the nuclear photoeffect.

As to radiothorium A. I. Alikhanov had kindly placed at our disposal a radiothorium preparation of 2 mg power. It was found in that case that the irradiated target gave about 1 deflection per milligram per minute, 35 minutes upon exposure. We used as mesothorium I a mesothorium I+radium solution, out of which the whole of radiothorium had been chemically eliminated. The solution was placed in a special barbator therefrom the rhadon could be blown out at will, and 3—4 hours after blowing the solution transmitted practically only the γ-rays of mesothorium I. The power of that mesothorium I preparation was equivalent to about 5 mg of radium metal. The manganese target was exposed to irradiation by the solution for 5 hours. As was expected, no effect whatever was discovered.

Unfortunately, we had at our disposal only 0.5 g of heavy water, kindly supplied by Prof. P. I. Lukirskij, but that was too little to obtain definite results even with a greater quantity of radiothorium in mixed mesothorium preparations than that which we happened to possess.

We therefore tested two mixed mesothorium I preparations, the age of which was known.

The measurements proved to be in satisfactory agreement with the radium and mesothorium I content as determined by the emanation method, no exact coincidences were, however, obtained.

The slight discrepancies may be accounted for both by the lack of precision of the determinations made by the emanation method, and by some peculiarities of the new method (the influence of the degree of concentration of the preparations, the fact that the latter were contained in glass ampoules, etc.).

We intend to go on with the work and to publish shortly a detailed report on the results obtained as also on what we shall have succeeded in doing with heavy water, a large amount of which has now been obtained.

In conclusion, we deem it a pleasant duty to place on record our gratitude to L. V. Mysovskij and I. V. Kurčatov for their valuable suggestions and remarks in connection with this work.

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BIOPHYSICS

EFFECT OF ELECTROMAGNETIC CENTIMETRE WAVES ON THE CENTRAL NERVOUS SYSTEM

By S. J. TURLYGIN

(Communicated by P. P. Lasareff, Member of the Academy, 31. VII. 1937)

The effect of electromagnetic waves—in particular centimetre waves—upon the central nervous system of a human being can, of course, be determined in many ways.

Although there are two quantitative methods which seem particularly convenient for this purpose—the psycho-galvanic reflex and the optical adaptometry methods. Both are most sensitive; the adaptometry method, however, is more convenient on account of its stability. We have therefore chosen it for our experiments.

These experiments have been carried out in the following way (1). A person after having rested for half an hour in full darkness was placed on a chair in front of an adaptometer, and was exposed to the light for five minutes. The sensitiveness of his eye was thereafter examined every five minutes. When the sensitiveness became constant, the patient was exposed to the effect of centimetre waves from a generator placed behind him and shielded by an iron screen. The faint noise of the spark generator and psychical excitement because of the new situation, immediately raised the nerve sensibility of the patient. Then the screen was noiselessly moved away and the waves could reach the head of the patient. This caused a sudden increase of the nerve sensitiveness which sometimes attained almost 200%.

The process on the whole resembles an analogous rising of the electrical sensitiveness of one eye during a fairly intensive 200 luxes illumination of the other. In both cases the excitability of the central nervous system increases immediately. But when light is thrown on the eye, the central nervous system is roused through the irritation of the optical nerve, while in our case there are either the perifiric nerves that transmit the effect of the waves to the central nervous system or the energy penetrates directly to the cerebrum and affects it.

An adaptometer after Academician P. Lasareff's was applied in the experiment (1).

The spark generator consisted of 50 vibrators, one centimetre long, placed on two planes in order that the energy radiated along the perpendicular line to the planes, provided the vibrator currents were synphase.

The density of the energy of centimetre waves was equivalent to 6 luxes of illumination intensity. It is supposed, however, that it was the highest limit of density, as the «brightness» of our electromagnetic waves was, of

course, weaker, owing to the different phases of vibrator currents. The «brightness» of our waves corresponded to such a dim light that makes the reading difficult. But even this small density of the energy of our waves produced a marked effect on the central nervous system.

The figure shows the nerve sensitiveness curve of the patient C. The patient had been in hospital for about two m nths and her nerve sensitiveness curve constantly sloped downwards. On her being admitted to the hospital her sensitiveness was equal to 108 units and in 46 days it fell to 70, sometimes fluctuating to 25%. The curve on the figure was obtained at the lowest point of one of such fluctuations.

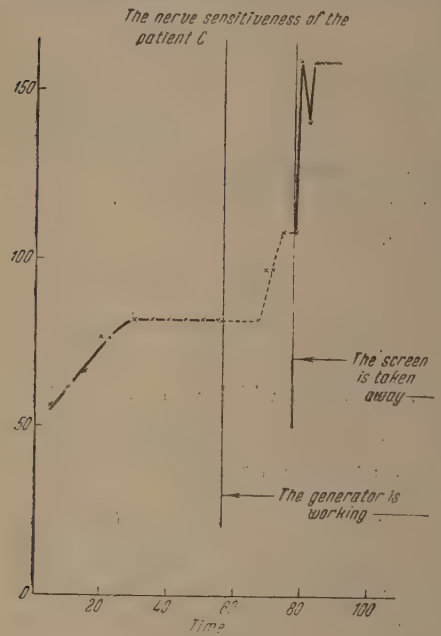

Fig. 1.

The curve shows that the normal nerve sensitiveness during complete silence was 82. It was 108 when the sparks of the shielded generator sounded. When the screen was taken away the sensitiveness rose to 159 and at this value it stopped and remained constant for ten minutes. When the screen was taken away the generator was working at full energy. The general increase in nerve sensitiveness owing to the effect of centimetre waves was 94%, before the screen was taken away it had been 32%.

The results of all experiments on other patients were the same although the increase in sensitiveness was not so high.

Besides this direct proof of the effect of centimetre waves on the central nervous system obtained by means of the sensitiveness curve, an indirect evidence has also been found. All the patients felt well after the experiments. The nerves appeared to have become quiet. Besides, all the patients slept much better (deeper and longer). Especially good results were obtained from experiments on the patient B. (a chemist, 52 years old). He was suffering from *angina pectoris* and had been in hospital for about two months. All this time he had insomnia and was given 0.1 g of luminal everyday to make him sleep; nevertheless he slept badly, heard people conversing and was conscious of his surroundings. The centimetre waves were applied, as their sleeping effect had been proved on other patients. The patient B. himself did not believe in it. At that time he was not given luminal.

The first treatment by centimetre waves having been applied for 10 minutes on the 20th of June, the patient fell asleep for about an hour and a half. When he awoke he read a newspaper and at 11 o'clock in the evening fell asleep again but slept badly till 3 o'clock in the morning. After dinner on the 21st he fell asleep, a thing he had never done before and slept a good, sound sleep. On the 21st in the evening the sensitiveness of his nervous system was examined again. During this examination he showed certain uneasiness and asked not to be left alone. At 6 o'clock in the evening he was given the second treatment of centimetre

waves for 5 minutes. He slept very well during the night («a sweet sleep»— as he said himself). He slept 7 hours and a half (for the first time after being admitted to hospital). On the 22nd, in the evening, while being examined on the sensitiveness of his nervous system he felt bad, was gasping for breath but refused categorically to give up the waves treatment. His sensitivity curve greatly oscillated. The treatment lasted 5 minutes. In the evening the patient B. got pains in his heart and had an extremely severe attack (anginae pectoris). Nevertheless, in spite of these pains the patient fell asleep at 10 o'clock in the evening and awoke at 3 o'clock in the morning. Further treatment was stopped because of this attack.

It should be noticed that the persons subjected to experiments always feel drowsy.

Thus the soothing and sleeping effect of centimetre waves is a real fact and it is advisable to consider the question about the treatment dosing in connection with the individuality of patients and the energy of the waves.

Conclusions

1. The influence of centimetre waves on the sensitiveness of the central nervous system has heen established.
2. A marked effect on the nervous system is obtained at a very low density of the centimetre wave energy.
3. Centimetre waves have a soothing influence on the nervous system.
4. Centimetre waves produce a strong sleeping effect, resulting in a sound, healthy sleep.
5. The dose and other effects of centimetre waves on the nervous system should be carefully studied.

In these preliminary experiments three treatments by centimetre waves within five minutes produced a good, sound sleep.

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CHEMIE

ÜBER DIR HYDROXOVERBINDUNGEN DES VIERWERTIGEN PLATINS (I)

Von A. A. GRÜNBERG und P. M. FILINOV

(Vorgelegt von N. N. Semenov, Mitglied der Akademie, d. 11. VIII. 1937)

In 1927 zeigten L. A. Tschugaeff und V. G. Chlopin, dass bei Einwirkung des Wasserstoffperoxyds auf die Verbindungen des zweivertigen Platins zwei Hydroxyle in trans-Stellung angelagert werden (1). In 1933 haben A. A. Grünberg und B. W. Ptizyn denselben Reaktionsverlauf unter Oxydation der Platosalze mittels $KMnO_4$ beobachtet (2).

Bezeichnen wir die Gesamtheit der mit dem Pt^{++}-Ion verbundenen Radikale mit R, so können wir die Reaktion mit H_2O_2 folgendermassen ausdrücken:

$$R-Pt^{II} + H_2O_2 \rightarrow R-\overset{\overset{OH}{|}}{\underset{\underset{OH}{|}}{Pt^{IV}}}.$$

Die entsprechende Reaktion mit $KMnO_4$ lässt sich dann ebenfalls durch die schematische Gleichung:

$$R-Pt^{II} + H_2O + O \rightarrow R-\overset{\overset{OH}{|}}{\underset{\underset{OH}{|}}{Pt^{IV}}}$$

schildern.

Durch die Einwirkung von H_2O_2 auf das Ammoniumtetrachloroplatoat konnten Tschugaeff und Chlopin das Salz $(NH_4)_2[PtCl_4(OH)_2]$ synthetisieren. Dieses Salz stellt ein kristallinisches orangefarbiges Pulver dar.

A. A. Grünberg und B. W. Ptizyn erhielten das Silbersalz dieser Reihe, indem sie das Silbernitrat auf das Produkt der Oxydation von $K_2[PtCl_4]$ mittels $KMnO_4$ in schwefelsaurem Medium einwirken liessen.

Aus verschiedenen Gründen schien es von Interesse, auch einige andere Salze der dihydroxo-tetrachloro-plate-Reihe zu isolieren.

Es ist uns aber nicht gelungen ein Hg^{+}- und ein Cs^{+}-Salz zu fassen. Dasselbe geschah auch, als wir versuchten das Kaliumsalz in substantia abzuscheiden. Anstatt $K_2[PtCl_4(OH)_2]$ erhielten wir unter allen Umständen stets $K_2[PtCl_6]$.

Diese Tatsache weist jedenfalls darauf hin, dass $K_2[PtCl_4(OH)_2]$ sehr löslich ist, im Gegensatz zum entsprechenden Verhalten des Ammoniumsalzes.

Solchein gewaltiger Unterschied in Eigenschaften des Kalium- und Ammoniumsalzes einer und derselben Säure ist sehr auffallend, da die Löslichkeitsverhältnisse der Kalium-und Ammoniumsalze gewöhnlich sehr nahe liegen. Nachdem unsere Versuche mit Cs^+-, Hg^+- und K^+-Salzen fehlschlugen, gingen wir zu den substituierten Ammoniumsalzen über.

Es hat sich herausgestellt, dass eine Reihe substituierter Ammoniumradikale und nämlich das Äthylendiammonium-Ion, Methylammonium-Ion und Pyridinium-Ion ebenfalls wie das NH_4^+-Ion dazu befähigt sind, verhältnissmässig schwerlösliche Dihydroxo-tetrachloro-platoate zu liefern. Dasselbe Verhalten zeigt auch das Tl^+-Ion. Dabei erweisen sich die Salze

$$\begin{bmatrix} CH_2NH_3 \\ | \\ CH_2NH_3 \end{bmatrix}[PtCl_4(OH)_2],\ (CH_3NH_3)_2[PtCl_4(OH)_2] \text{ und auch } Tl_2[PtCl_4(OH)_2]$$

als ziemlich beständige Produkte. Das Pyridiniumsalz ist dagegen sehr unbeständig und geht sehr leicht in cis-$[PtPy_2Cl_4]$ über. Diese Umwandlung ist so rasch, dass es sogar unmöglich ist das Salz $(PyH)_2$ $[PtCl_4(OH)_2]$ in ganz reinem Zustande zu isolieren.

Die Abkömmlinge des Äthylendiammoniums und des Methylammoniums sind, ihren Eigenschaften nach, dem schon früher beschriebenen Salz $(NH_4)_2$ $[PtCl_4(OH)_2]$ ganz analog. Sie bieten gut ausgebildete rosa-gelbe kristallinische Substanzen dar. Das Thallium-Salz ist dem Silbersalz $Ag_2[PtCl_4(OH)_2]$ sehr ähnlich. Es stellt ein feinkristallinisches gelbes Pulver dar.

Alle von uns erhaltenen, $[PtCl_4(OH)_2]^=$-Anion enthaltenden Salze zeigen in wässriger Lösung eine deutlich alkalische Reaktion und lassen sich mittels Salzsäure titrieren. In Gegenwart von Methylorange verhalten sie sich dabei wie annähernd einsäurige Basen (nur eine OH-Gruppe lässt sich titrieren), in Gegenwart von Thymolblau sind aber beide OH-Gruppen titrierbar. Solchein Verhalten deutet auf eine merkliche Verschiedenheit der basischen Funktion der beiden OH-Gruppen hin.

In dieser Hinsicht erinnern diese trans-Basen des vierwertigen Platins an das entsprechende Verhalten der trans-Basen des zweiwertigen Platins, die schon früher von einem von uns gemeinsam mit D. J. Rjabtschikow untersucht worden sind [3]. Ceteris paribus sollen die Hydroxoverbindungen des vierwertigen Platins schwächere Basen sein, als die entsprechenden Abkömmlinge des zweiwertigen Platins.

In unserem Falle werden aber die basischen Eigenschaften des $[PtCl_4(OH)_2]$-Ions infolge des Bjerrum-Brönsted'schen Effekts verstärkt.

EXPERIMENTELLER TEIL

Darstellung und Eigenschaften von $\begin{bmatrix} CH_2NH_3 \\ | \\ CH_2NH_3 \end{bmatrix}[PtCl_4(OH)_2]$

0.4 g $K_2[PtCl_4]$ werden in einigen Kubik-Centimetern Wasser gelöst und mittels Zugabe von 2 cm^3 Perhydrol in sehr schwach alkalischer Lösung (Zugabe von einigen Kristallen K_2CO_3) oxydiert. Nach dem Erkalten der Lösung wurde sie mit einer Lösung von Äthylendiammoniumchlorid versetzt. Die letzgenannte Lösung wurde durch Neutralisation von Äthylendiamin mittels konzentrietrter HCl in Gegenwart von Methylorange vorbereitet.

Bald werden gut ausgebildete rosa-gelbe prismatische Kristalle abgeschieden. Die Kristalle wurden abgesaugt, mit kaltem Wasser gewaschen und

erst in Exsiccator über H_2SO_4 und dann im Trockenschrank bei 90° getrocknet.

Analyse. Ber. für $\left[\begin{matrix}CH_2NH_3\\|\\CH_2NH_3\end{matrix}\right][PtCl_4(OH)_2]$: 45.08%Pt; 32.53%Cl,
Gef. 44.94%Pt; 32.75%Cl.

Die Substanz ist schwerlöslich im Wasser. In Säuren und Basen löst sie sich sehr leicht auf.

Titration mit HCl. Bei der Titration von 0.0541 g des Salzes aufgelöst in 150 cm³ Wasser mit Salzsäure in Gegenwart von Methylorange wurden 1.38 cm³ HCl ($T=0.004152$) verbraucht. Theoretisch mussten zur Neutralisation beider OH-Gruppen 2.19 cm³ HCl verbraucht werden. Somit wurden ca 62% der theoretischen HCl-Menge verbraucht. In einem anderen Versuch verbrauchten wir 61% der theoretischen Säuremenge.

In Gegenwart von Thymolblau werden aber beide OH-Gruppen titriert (ber: 3.08 cm³ CHl; gef.: 3.20 cm³ HCl).

Darstellung und Eigenschaften von $(CH_3NH_2)_2[PtCl_4(OH)_2]$.

Dieses Salz wird in derselben Weise wie das vorherbeschriebene hergestellt. Es stellt rosa-gelbe prismatische Kristalle dar.

Analyse. Ber. für $(CH_3NH_3)_2[PtCl_4(OH)_2]$: 44.87%Pt; 32.61%Cl,
Gef.: 44.83%Pt; 32.58%Cl.

Titrationsergebnisse:

a) Mit Methylorange I. Ber.: 3.45 cm³ HCl; gef. 1.85 cm³ HCl.
d. h. 53.2% der theoretischen Menge.
II. Ber.: 1.8 cm³ HCl; gef.: 1.0 cm³ HCl,
d. h. 56% der theoretischen Menge.

b) Mit Thymolblau. Ber.: 2.41 cm³ HCl; gef.: 2.50 cm³ HCl,
d. h. die theoretische Menge für zwei OH-Gruppen.

Titration von $(NH_4)_2[PtCl_4(OH)_2]$ mittels HCl.

a) Mit Methylorange. In einem Versuche wurden 64% der zur Neutralisation beider OH-Gruppen erforderlichen Säuremenge vebraucht, im anderen Versuch—62%.

b) Mit Thymolblau. Ber.: 2.90 cm³ HCl; gef.: 2.75 cm³ HCl.

Auch in diesem Falle sind in Gegenwart von Thymolblau beide Hydroxo-Gruppen titrierbar.

Versuche zur Darstellung von $(PyH)_2[PtCl_4(OH)_2]$

Beim Zusammenbringen wässriger Lösungen von PyHCl und $K_2[PtCl_4(OH)_2]$, die laut der Gleichung:

$$2PyHCl + K_2[PtCl_4(OH)_2] \rightarrow (PyH)_2[PtCl_4(OH)_2] + 2KCl$$

reagieren müssten, wurde stets ein Gemisch rosa-gelber nadelförmiger Kristalle der gesuchten Verbindung und noch einer hellgelben feinkristallinischen Substanz erhalten. Es ist uns nicht gelungen das Salz $(PyH)_2[PtCl_4(OH)_2]$ in reiner Form darzustellen, da es sich sehr rasch in die ebengenannte feinkristallinische Substanz, die nichts anderes ist als cis-$[PtPy_2Cl_4]$, umwandelt. Behandelt man das eben erwähnte Gemisch zweier Krystallarten mit Wasser, so geht das $(PyH)_2[PtCl_4(OH)_2]$ in Lösung. Aus der Lösung wird aber bald chemisch-reines $[PtPy_2Cl_4]$ ausgeschieden.

Analyse. Ber. für $[PtPy_2Cl_4]$: 39.42%Pt; 28.65%Cl.
Gef.: 39.39%Pt; 28.92%Cl.

Die cis-Konfiguration des Salzes wurde durch den Vergleich dessen Eigenschaften mit denen der speziell-synthesierten geometrischen Isomeren der Zusammensetzung $(PtPy_2Cl_4)$ festgestellt.

Insbesondere liess sich die Identifikation auf Grund der Löslichkeit in Chloroform, der Farbe, der Kristallform und der Schmelztemperatur ausühren (Tabelle).

Eigenschaft	$[PtPy_2Cl_4]$ aus $(PyH)_2[PtCl_4(OH)_2]$	cis-$[PtPy_2Cl_4]$	trans-$[PtPy_2Cl_4]$
Farbe	Gelb	Gelb	Weiss (sehr schwach gelblich)
Kristallform	Gut ausgebildete Nadeln oder ausgezogene Prismen	Nadeln oder ausgezogene Prismen	Sehr kleine Kristalle von schwer nachweisbarer Form
Löslichkeit in $CHCl_3$	Merklich löslich	Merklich löslich	Fast unlöslich
Schmelzpunkt (unter Zersetzung)	250°	247°	260°

Es kann bei oberflächlicher Betrachtung die Umwandlung von $(PyH)_2[(PtCl_4(OH)_2]$ in das cis-$[PtPy_2Cl_4]$ etwas schwer begreiflich vorkommen. Man könnte ja die Bildung des trans-Isomeres eher erwarten. Zieht man aber die trans-Wirkung-Regelmässigkeit in Betracht, so wird alles klar.

Der Umwandlungsvorgang spielt sich folgendermassen ab:

a) $(PyH)_2\left[\begin{smallmatrix} & OH & \\ Cl & Pt & Cl \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right] \rightarrow (PyH)\left[\begin{smallmatrix} & H_2O & \\ Cl & Pt & Cl \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right] + Py,$

b) $(PyH)\left[\begin{smallmatrix} & H_2O & \\ Cl & Pt & Cl \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right] + Py \rightarrow (PyH)\left[\begin{smallmatrix} & Py & \\ Cl & Pt & Cl \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right] + H_2O.$

Die sich in trans-Stellung zum Pyridinmolekül befindende OH-Gruppe erscheint sehr schwach kontrapolarisiert und deswegen sind deren basische Eigenschaften bedeutend abgeschwächt. Unterdessen sind die in trans-Stellung zu den Chlor-Ionen stehenden Chlor-Ionen labilisiert und lassen sich daher leicht gegen Wasser und darauffolgend gegen Pyridinmoleküle austauschen:

c) $\left[\begin{smallmatrix} & Py & \\ Cl & Pt & Cl \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right]^- + H_2O \rightarrow \left[\begin{smallmatrix} & Py & \\ Cl & Pt & H_2O \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right]^0 + Cl^-,$

d) $\left[\begin{smallmatrix} & Py & \\ Cl & Pt & H_2O \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right]^0 + Py \rightarrow \left[\begin{smallmatrix} & Py & \\ Cl & Pt & Py \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right]^0 + H_2O$

und endlich

e) $\left[\begin{smallmatrix} & Py & \\ Cl & Pt & Py \\ Cl & & Cl \\ & OH & \end{smallmatrix}\right] + HCl \rightarrow \left[\begin{smallmatrix} & Py & \\ Cl & Pt & Py \\ Cl & & Cl \\ & Cl & \end{smallmatrix}\right] + H_2O.$

Die Leichtigkeit der Umwandlung von $(PyH)_2[PtCl_4(OH)_2]$ wird dadurch bedingt, dass PyH^+-Ion starksaure Eigenschaften besitzt (mit anderen Worten heisst es, dass Pyridin eine sehr schwache Base ist).

Da NH_3 und besonders CH_3NH_2 viel stärkere Basen sind als Pyridin, so erscheint es ganz natürlich, dass im Falle von $(NH_4)_2[PtCl_4(OH)_2]$ und $(CH_3NH_3)_2[PtCl_4(OH)_2]$ unter denselben Bedingungen derartige Umwandlung nicht beobachtet wird.

Für den Fall des Äthylendiammoniumsalzes ist eine partielle «Autoneutralisation» wohl zu erwarten, da die zweite K_B des Äthylendiamins gering ist.

Der Versuch zeigt tatsächlich, dass die deutlich alkalisch reagierende Lösung von $\begin{bmatrix} CH_2NH_3 \\ | \\ CH_2NH_3 \end{bmatrix}[PtCl_4(OH)_2]$ nach dem etwa einstündigen Erhitzen auf dem Wasserbade praktisch neutral wird (auf Methylorange).

Es ist wahrscheinlich, dass dabei eine Umwandlung vom Typus:

$$\begin{bmatrix} CH_2NH_3 \\ | \\ CH_2NH_3 \end{bmatrix}\cdot\begin{bmatrix} OH \\ Cl\ Pt\ Cl \\ Cl\ \ Cl \\ OH \end{bmatrix} \rightarrow \begin{matrix} CH_2\ NH_2 \\ | \\ CH_2NH_3 \end{matrix}\!\!\!

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PETROGRAPHY

TINBEARING GRANITOIDS OF BORSHCHOVOCHNY RANGE, EASTERN TRANSBAIKALIA

By I. PREOBRAŽENSKIJ

(Communicated by F. J. Loewinson-Lessing, Member of the Academy, 14. VII. 1937)

Determination of the distinguishing features of the granitoids associated with tin deposits is of great importance in prospecting for tin. In order to expose these features, investigations have been carried out in the Borschovochny range, Eastern Transbaikalia, by the Expedition of the Academy of Sciences of the USSR.

The granitoids of the Borshchovochny range are clearly separated into two groups, one associated with the cassiterite deposits and the other without such connection.

Tinbearing granitoids are of grey colour. They include pegmatite nests, stocks and veins. The structure of these rocks varies from equigrained to clearly porphyritic, from ataxitic to gneissic. In the porphyritic varieties the phenocrysts are represented by the potassium feldspar, chiefly microcline. The rock is composed chiefly of quartz, microcline and sometimes orthoclase, acid plagioclases, of the albite-andesine series, and biotite; turmalin is not uncommon. As accessories are usually recognized apatite and zircon, sometimes rutile. Titanite has a sporadic distribution but sometimes is plentiful.

The main characteristic of the tinbearing granitoids is not their mineralogical composition, but the traces of the secondary alterations of the rock represented by clastic structures, and particularly in the replacement of the plagioclase by potassium feldspar and quartz, and of potassium feldspar by quartz. Besides, very peculiar is almost the entire absence of chlorite, epidote and calcite.

Clastic structure is usually represented by mosaic extinction of the quartz grains and by breaking of the larger grains into small ones. The potassium feldspars are almost always deformed and show an uneven extinction. The twin plates are not infrequently bent and have fractures filled by quartz. The biotite plates are also bent and show a wavy or spotlike extinction in the sections close to those parallel to the cleavage. The pertites represent band-, vein- and spotlike varieties with various indices of refraction.

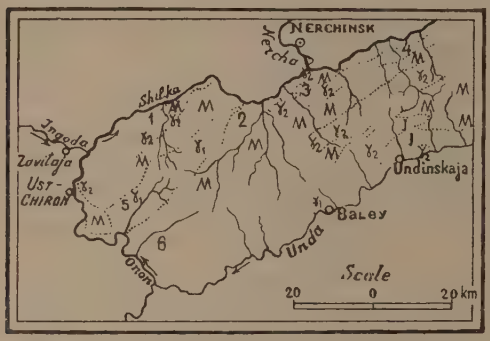
The plagioclases are enriched in albite and the reaction rim is sometimes developed on the border line with potassium feldspar. More often microcline is intruding into plagioclase with sharp borders between these minerals. Sometimes the rest of plagioclase embedded in potassium feldspar represents only a small grain of irregular form.

Quartz grains have often ragged rims, the dents of one grain are intimately interlocked with those of the other. That shows the recrystallization of quartz which possibly is due to the hydrothermal processes. Quartz corrodes the plagioclase and microcline grains.

The clastic structure, the corrosion of the dlagioclase by potassium feldspar and quartz, and pertitization are common also in pegmatite veins of the tinbearing granitoids and in the adjoining crystalline schists. Apparently all these processes have been taking place after the formation of the pegmatites.

The tinbearing granitoids are widely distributed in the explored region of Borshchovochny range.

The non-tinbearing granitoids are represented by granodiorites and quartz diorites of the Makarova intrusion, caledonic (according to Scheineman) intrusion of Aprelkova river and quartz diorites of Lukina valley. These granitoids are almost always greenish coloured by chlorite.



Schematic map of the investigated part of Borshchovochny range: 1—Konga r.; 2—Urulga r.; 3—Urguchan r.; 4—Borshchovskaja dell, 5—Telenguj r.; 6—Makarova r.; 7—Zmeevka r.; м—metamorphic schists, gneiss: γ_1, γ_2—tinbearing and non-tinbearing granitoids; J—Jura Mountains.

Potassium feldspar is much sparser than in tinbearing granitoids; not infrequently it fills the interstices between the plagioclase grains. Plagioclases are of higher numbers and mostly replaced by sericite, chlorite and epidote. The idiomorphic phenocrysts of plagioclases are not uncommon in potassium feldspar. Biotite is changed into chlorite, sometimes entirely. Clastic structure is less expressed. Zircon is almost rare.

The secondary alterations are expressed in the turmalinization, chloritization, epidotization and calcitization. But the introduction of boron was not accompanied by introduction of tin, or, at least, by formation of tin deposits. Tinbearing granitoids and pegmatite veins are sometimes also turmalinized, but besides that there are brought in alkali and silica; in the non-tinbearing granitoids turmalinization was followed by formation of chlorite and epidote and, finally, of calcite. Therefore, a theory may be set up that for the introduction of tin or for the formation of tin deposits the presence of boron (in turmaline) was not sufficient and that the alcali are also necessary, sodium in particular.

Spectroscope showed the presence of tin in tinbearing granitoids, though traces only, and the absence of it in the non-tinbearing granitoids.

Both types of granitoids are found in the Borshchovochny range in stripes stretched in the north-eastern direction. There are four such stripes; from the north-west to the south-east they are: the tinbearing granitoids stretching from Zavitaya and Ust-Chiron to the Volchya river; non-tinbearing but goldbearing granitoids of Telenguy and Makarova rivers; the tinbearing granitoids containing tin deposits of Urguchan river (Ussovsky and Mochovaya deposits); non-tinbearing granitoids including Baleyskoje and Kazakovskoje gold-ore deposits. It is possible that the tin deposits on the Zmeevka and Lukina valleys belong to the more southern fifth stripe.

The absence of distinguishing features of tinbearing granitoids may point to the absence of tin deposits; but the presence of these features would only

indicate the possibility of finding tin deposits, but it would not confirm their presence. It is, of course, understood that determination of the distinguishing features is correct.

A comparison of the chemical analyses of tinbearing and non-tinbearing granitoids has led to the conclusion that these granitoids cannot be distinguished by their chemical composition.

As seen from the literature the tinbearing granitoids can be divided into three groups. The first one represents granitoids containing zinnwaldite, topaz, fluorite or other fluorine minerals; they are often altered to greisen or topaz rock, particularly if near the tin veins.

The granitoids of the second group contain fluorine but in insignificant quantity; boron is not uncommon in them (in turmaline). They show no greisenization nor topazization; near the tin veins (pegmatites) they are not altered; secondary alterations are expressed in the enrichment by alkali and quartz.

The richer tin deposits are usually associated with ore granitoids of the first group; while with the second group are associated the poor ones. It is possible that the granitoids of the second group represent sometimes deeper horizons of the same intrusive which is near the surface enriched by volatiles and tin. According to some authors tin is capable of being transported as alkali stannite; but it is possible that tin concentration in these solutions is less than in fluids containing fluorine (or chlorine). Therefore, the alkali solutions are not forming rich tin deposits. The granitoids of the Borshchovochny range belong to the second group.

The granitoids of the third group are not so closely associated with tin deposits as those of the first and second group. They lie at some distance from the tinbearing veins in metamorphic rocks or in effusives considered as derivates of these granitoids. The alterations of the granitoids of the third group are very closely resembling those of the granitoids of the second group, but their effusives are highly turmalinized, silicified and pyritizied, sometimes propylitizied. Enrichment by sulfides and the presence of tin sulfides are very common in tin veins associated with the granitoids of the third group. Tin deposits in the effusives of the granitoids of the third group are the richest.

Pegmatite veins of the explored tin deposits of Borshchovochny range contain very little cassiterite. It is difficult to say whether the eroded upper part of the ore zone was richer in cassiterite, but it can be supposed that the higher horizons have lower temperatures, more favourable for the formation of cassiterite, which was of lighter colours. Therefore it seems possible that the erosion of the upper horizons of the granitoids and the deposition of the transported materials resulted in the enrichment by cassiterite of the sediments near the Borshchovochny range.

It would be of great interest to elucidate the genesis of these sediments by a study of their structure and mineralogical composition and a comparison of their minerals with those of the igneous and metamorphic rocks of the range, in order to determine the possibility of tin formation. It may be expected that such investigations will solve the problem of workable tin deposits more quickly than prospecting tin ore deposits of the Borshchovochny range, the explored part of which does not contain sifficient tin concentrations.

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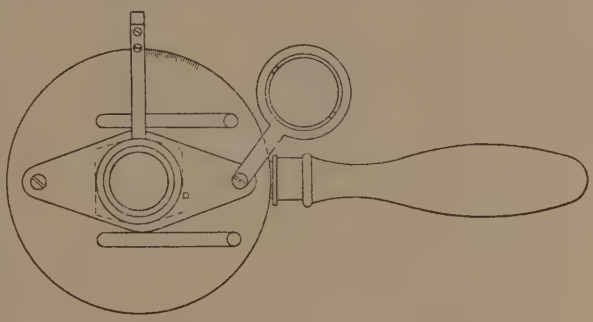
MINERALOGY

ON THE POCKET MINERALOGICAL OR POLARIZING MAGNIFIER

By V. V. ARŠINOV

(Communicated by V. I. Vernadsky, Member of the Academy, 16.VIII. 1937)

The author had the pleasure of demonstrating both to the members of the Meeting of Mineralogists of USSR, held in Moscow in May 1937, and to the members of the XVII Cession of the International Geological Congress a small instrument, shown on the Figure. This instrument named «the pocket mineralogical or polarizing magnifier» allows during field work to identify conveniently non-opaque minerals and rocks by petrographic optical methods. The instrument consists of a disc, graduated on the circumference, holding the object glass and attached to a handle. On the two sides of the disc round polaroid plates are placed, which may be rotated simultaneously (syngon), with reading the degrees of rotation on the circumference of the disc. Over the polaroid-polarizer, directly under the object glass, a round glass plate rotating simultaneously with the polarizer is placed, with a cross cut on it.



Below the glass plate is a slit for inserting the compensators (gypsum plate, red 1st order, graduated quartz wedge...) and light filters.

Placed over the polaroid-analyser there is the magnifier ($\times 10$ or $\times 16$). Divisions on the quartz wedge may be seen through the lens simultaneously with the outlines of grains or of sections of minerals in slides of the rock and the path difference of birefringent minerals may be determined by the compensation band.

In order to observe the pleochroism the polaroid-analyser or the polaroid-polarizer may be removed from the ring in which they rotated. To compensate the little coloration of the polaroid, a plate with a corresponding light filter may be inserted into the slit over the polarizer or in place of the polarizer or analyzer.

For observations of conoscopic-interference figures, e. g. of a muscovite plate, the magnifier is placed aside, as is shown on fig. 1, and the phenomenon

is observed by closely approaching the polaroid-polarizer or the polaroid-analyzer to the eye.

In order to observe the interference figures in a section of a small grain of a mineral in a rock slide over the mineral grain, better not covered by a glass, the microlens of the microconoscope is introduced. The preparation of the microconoscope is described by N. Vedeneeva and A. Kolotuškin (1). Accurate microballs of a small size, about 1 mm in diameter are also readily obtained by another simple method in the Lomonosov Institute of the Academy of Sciences. Instead of a microball, half immersed in celluloid plate, use may be also made of a cover glass with a hemispheric lens (radius of curvature 0.5—0.6 mm) cemented to it with canada balsam.

A thin glass plate with some air bubbles also can be used as a microconoscope plate.

The disc with polaroids may be inserted in a cleft or split of a block wood or ruler (24 cm long, 3—4 cm high and 2—3 cm wide). Since any of the diameters of the disc may be placed parallel to the length of the ruler, the combination of the disc with the polaroids and a ruler may replace to a certain extent the conoscope and the Fedorov stage with two axes of rotation. The angle of optic axes in a mica plate may be determined by means of an instrument in the following way. The ruler with the disc (on the level of the eyes arranged by means of a photographic stand) is put upon a sheet of paper, fixed with knobs on the plate trestle board. By moving the ruler with the attached disc on the paper sheet, the observed point of emergence of every of the optical axes of a mica plate is aligned with some signal, e. g., a telegraph pillar or a straight trunk of a tree or an electric lamp which is seen through the mica and polaroids, and corresponding lines are drawn on the paper with the aid of the ruler.

The picture, of the optical axis may be also fixed at the cross of the frosted glass of the photographic apparatus.

The angle between both the lines that have been drawn on the paper sheet, will correspond to the angle of the optic axes of the mica.

To the same end the Wulff plat may be used by rotating the ruler centre about the centre of the plat and reading the grades on the circumference of the plat.

For the observations of the phenomena taking place in characteristic directions of small mineral grains ($<3\,\mathrm{mm} > 3\mu\mu$) in thin sections of rocks and for measuring the angles between these directions the disc with polaroids in combination with a telemagnifier or a telemicroscope, like those made, for instance, by Zeiss (2), may be used.

The maintenance of the extinction while rotating the ruler with the disc around the axis perpendicular to the ruler and parallel to one of the two directions of extinction in the section of the mineral will be an evidence for the latter being an uniaxial one.

A disc of a greater radius with an attached mechanism for a parallel shifting of the object glass with a rock slide may be used in petrographic investigations for measuring the angles between the optic axis and the perpendicular to the slide of such minerals as quartz and calcite.

By fixing the pocket mineralogical or polarizing magnifier in front of the microscope lamp or a classroom lantern good pictures of rock microsections in beautiful interference colours may be obtained on a screen, using the magnifier of the instrument as an objective.

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BIOCHEMISTRY

VITAMIN C IN GERMINATING SEEDS

By K. L. POVOLOCKAJA

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It is only in a small degree that the physiology and biochemistry of plants have contributed to the recent achievements in the study of vitamins. The question of how the plant itself is affected by these compounds has so far been left practically out of account. Judging, however, from the tremendous physiological activity of these substances in the living organism it may be thought that the vitamins produced by the plant ought to play an essential part in the processes of development and metabolism of the plant itself.

This paper is an attempt to contribute to the solution of a small part of the questions arising in this connection. Vitamin C has been selected for study on account of its strong oxidizing-reducing properties, and also because an exact quantitative chemical method of determination is available with regard to this vitamin. As to the object of investigation, germinating seeds were chosen on account of the fact that the transition from quiescence to germination involves profound changes in the seeds and also their internal reconstruction, thus bringing the most dynamic material within the field of observation.

Without considering in detail the work of numerous investigators on the formation of vitamin C during the germination of various seeds, we may mention that most of that work was done by the biological method on guinea pigs, a method that does not afford the possibility of following step by step the formation of vitamin C in the plant.

Still, the earliest investigators of vitamins ([2],[3]) had observed the absence of vitamin C in dry seeds and its appearance on germination. Honeywell and Steenbock ([4]) found that the presence of oxygen was indispensable for vitamin C to form in germinating seeds. In working with rice seeds, Matsuoka ([6]) found that light was not absolutely necessary for the formation of that vitamin, but in many cases stimulated its accumulation. More detailed work was done by Virtanen ([8]) and collaborators, who got within a nearer distance of establishing a connection between the accumulation of vitamin C and the development of the plant than did any of the other investigators. They discovered the stimulating action of this vitamin on the growth of the plant and attributed to it the function of the phytohormone of growth. An attempt to connect the action of vitamin C with processes of oxidation was made by Rubin and Stračickij ([7]), while following up the accumulation of vitamin C in connection with the activity of catalasis and peroxidasis in growing cabbage and tomatoes, but no definite results were obtained. More definite data recently

obtained in this respect by Hopkins [5] and Engelhardt and Bukin [9] indicate that vitamin C takes a direct part in the breathing of some vegetable tissues.

Method. In these experiments we investigated germinating seeds transplanted without previous swelling into quartz sand previously washed and annealed, in darkness, at 25°C. The humidity of the sand was maintained at 60% of its total moisture holding capacity. The duration of each experiment was as a rule 12 days, determinations being made on the 1st, 3rd, 5th, 9th and 12th day of germination. The experiments were made in 3, 4 or more sets.

In addition to the determination of vitamin C by Bukin's (1935) chemical method, the following determinations were made: energy of breathing by Warburg's manometric method; activation of peroxidasis by Bach and Zbarsky's (1911) method, and activation of catalasis by Bach and Oparin's (1922) method. In every instance, the weight of 100 plants and the percentage of dry matter were determined. All the calculations were made with reference to 100 g raw weight, 100 g dry matter and 100 plants.

Vitamin C Accumulation Energy during Seed Germination of Leguminous Plants and Cereals

The dynamics of the production of vitamin C by germinating seeds were studied on four varieties of peas and four varieties of wheat. Considerable differences in the accumulation of vitamin C were found to exist between the different varieties of either peas or wheat. Thus, peas of the Victoria Mandorf variety had accumulated to the 12th day of germination 95 mg of vitamin C per 100 g of dry matter, as against 194 mg accumulated by the Rikhlik variety. As regards the wheats, Gordeiforme had accumulated in the same space of time 108 mg, and Durable 238 mg of that vitamin.

It is of interest to note that most of the leguminous plants studied by us (peas, kidney bean, pea-nut, bean) form vitamin C at practically the same rate i. e. about 147—209 mg% to the 12th day of germination, the only exception being the soy bean with 90 mg%. The differences between the various species of leguminous are thus no greater than those between different varieties.

Much wider differences are observed between the cereals: thus to the 12th day of germination, wheat held 143 mg ascorbinic acid per 100 g dry matter, barely 116 mg, maize 48 mg, and rice only 32 mg. This difference was far in excess of those intervariety differences that we observed.

Still greater differences have been found to exist between groups of leguminous plants and cereals with regard to the rate of formation of vitamin C. This being most obvious in the very first days of germination (Table 1).

Table 1

Accumulation of Vitamin C during the Germination of Seeds of Leguminous Plants and Cereals (in mg per 100 g of dry matter)

Species	Dry seeds	Days of germination				
		1	3	5	9	12
Beans	0.0	5.8	48.1	149.5	169.6	209.7
Peas	0.0	16.1	57.2	89.8	112.3	169.9
Kidney beans	0.0	29.4	37.3	84.2	153.6	156.9
Pea-nut	0.0	18.0	69.7	81.5	106.8	147.6
Soy beans	0.0	7.7	77.6	100.9	80.6	90.9
Wheat	0.02	5.0	11.5	22.4	108.7	143.8
Barley	0.0	4.6	12.9	28.6	53.9	116.9
Maize	0.0	3.8	24.3	53.2	52.5	48.3
Rice	0.0	0.49	2.20	3.5	21.7	32.3

As may be seen from the above table, leguminous plants produce vitamin C in a much more energetic manner than cereals.

The above data were obtained with seeds of the same year's harvest. By observing the production of vitamin C by seeds of different years' harvests, we have found that the longer the seeds had been allowed to lie the slower was their growth and the lower the vitamin C content shown by them. This induced us to follow up the accumulation of vitamin C by seeds that had been lying so long as to have fully or partially lost their germinating power.

The experiments, made on seeds of wheat, rice, kidney beans, soy beans, etc., have shown that, in losing their germinating power fully or partially, the seeds lose to the same extent their ability to form vitamin C. Absolutely non-sprouting seeds fail to show as much as traces of vitamin formation. This shows the very great importance of vitamin C in the process of germination and apparently also in the subsequent life of the plant.

Besides, this may suggest a new method of rapid determination of the germinating power of seeds, the details of which are now being elaborated.

Accumulation of Vitamin C by Various Portions of the Seed in Leguminous Plants and Cereals

The fact that, as noted above, various species of leguminosae and cereals accumulate vitamin C to a different extent, has induced us to study in greater detail the dynamics of the formation of that vitamin in different parts of the seed of both leguminosae and cereals.

The cotyledons of all the leguminosae, even if deprived of their radicle, can form vitamin C independently, while the endosperm of cereals is devoid of such a power. In the presence of a germ in the endosperm, only traces of vitamin C can be discovered, and no vitamin C whatever is formed if the germ has been removed.

Table 2

Formation of Vitamin C in Whole Seeds in Cotyledons and in the Endosperm on the 3rd Day of Germination

Plant or its part	Leguminosae		Cereals	
	Peas	Kidney beans	Wheat	Maize
Whole plant	40.6	8.5	28.7	20.8
Cotyledons or endosperm	97.2	21.1	0.0	0.0

These data are of undoubted interest. The fact that the seeds of leguminosae take but 1—3 days to form large quantities of vitamin C is apparently due to the ability of the cotyledons of leguminosae to synthesize that vitamin. Since whole plants produce less vitamin C than separate cotyledons it may be supposed that, in the first days of germination, the stem and the rootlets consume in their metabolic process a greater amount of vitamin C than they produce and draw additional ascorbinic acid from the cotyledons.

The endosperm of cereals, however, cannot synthesize vitamin C so that, since the very first days of germination, the germ has to produce itself all the vitamin it requires, hence the slower rate of its formation in cereals.

It is of interest to note that, biologically speaking, the endosperm differs utterly from cotyledons. Whereas the function of the former is to store up matter in reserve for the future plant, the latter perform that function only temporarily, being virtual leaves.

The Participation of Vitamin C in Oxidizing Processes

As stated above, the energy of respiration was in all cases determined along with vitamin C, the data obtained being partly shown in Table 3.

Table 3

The Energy of Respiration as Compared with the Vitamin C Content in the Seeds on the 3rd Day of Germination

Plant	Material tested	Vitamin C in mg per 100 g of dry matter	Energy of respiration in mm^3 of O_2 consumed in 10 min. per 1 g of dry matter
Kidney beans . .	Seeds capable of germination	37.2	99.3
	Seeds incapable of germination	0.0	4.5
Peas	Whole plant	40.5	183.6
	Cotyledons	97.2	295.7
Maize	Whole plant	20.8	23.3
	Endosperm	0.0	3.5
Wheat	Whole plant	11.5	160.3
Rice	» »	2.2	23.7

The energy of breathing may be seen to be well correlated with the storing-up of vitamin C. It is the close connection between these two processes that induced us to study simultaneously the formation of vitamin C in germinating seeds, the energy of breathing, and the activity of ascorbinasis.

Table 4

Activity of Ascorbinasis and Energy of Breathing of Pea Sprouts

Days of germination	Activity of ascorbinasis in mg of ascorbinic acid oxidized per 1 hour to 1 g of sprouts	Consumption of O_2 in mm^3 sufficient to ensure the fermentation of 1 g of sprouts per 1 hour	Actual consumption of O_2 in mm^3 per 1 hour to 1 g of sprouts
0	Traces	—	Not determined
1	1.8	115	90
3	5.5	350	408
5	10.0	636	240
9	12.0	700	390

It is, thus, seen that the ascorbinic acid + ascorbinasis system can fully ensure the consumption of oxygen with the energy of respiration observed.

The above data thus confirm the opinion that vitamin C is a carrier of hydrogen from the substances burnt towards the oxygen and that it takes a direct part in the respiratory act ([5],[6]). To the writers the most essential fact is that the close connection between the storing-up of ascorbinic acid and the increased energy of respiration is not a fortuitous, but a causal one.

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AGROCHEMISTRY

METHOD OF RAPID DETERMINATIONS OF CHLORINE IN PLANTS

By A. G. ŠESTAKOV and A. P. KAČEEV

(Communicated by D. N. Prianishnikov, Member of the Academy, 13. VII. 1937)

Determinations of chlorine in plants are now being more frequently made in the USSR than formerly. This is mainly associated with the discovery of the Solikamsk potassium salts and with their widespread application both raw and prepared. Determinations of chlorine in plants enable us better to understand the effect of potassium salts on the yield and quality of cultivated plants. The data found in literature indicate that the chlorine content varies very considerably both with the properties of the variety concerned and the conditions of nutrition. The chlorine-ion possesses a much greater power of penetration into plants than PO_4, SO_4 or CO_3. The introduction of KCl, NaCl, NH_4Cl, and other chlorine salts, therefore, leads to a marked rise in the chlorine content of plants. The energetic penetration of the chlorine-ion into plants also produced a noticeable change in the conditions of the manifestation of antagonism between the different chloride cations. The chlorine content is especially high in plants when the chlorides of the nutrient medium are salts of univalent cations.

In plants, chlorine occurs in considerable amounts in the vascular system as soluble salts. The presence of chlorine in plants as soluble salts of potassium, sodium, and other cations produces an increase in moisture content, a rise in osmotic pressure of the cell sap, which may facilitate the outflow of carbohydrates from the leaves. An increase in the water content of plants produces a fall in the content of chlorophyll in the chlorides of the leaves. Literature also records cases of a certain fall in chlorophyll in the chlorides even when referred to dry matter. A high chloride content in potato hinders the formation of starch and lowers the quality of the tuber yield. This, however, does not occur in those plants which accumulate soluble carbohydrates.

In a number of organic substances, chlorine is usually determined after dry incineration in a specially adopted tube in a stream of oxygen. Konfer recommanded the use of platinum as a catalyser for this purpose. The transportable universal Denstedt apparatus is most convenient for this operation of incineration. Carius proposed an addition to the lime method (incineration in the presence of CaO) of determining halogens. A sample, weighing 0.1—0.2 g, is acidified, in the presence of $AgNO_3$, with fuming HNO_3 in a tube of Jena glass in a Carius furnace. F. Pregl advises [3] the use of a tube containing beads, or a spiral glass rod, and platinum contact stars to incinerate matter in determining haloids.

The dry incineration of vegetable substances was up till now frequently applied in the quantitative determination of the chlorine content of plants.

This method, however, requires the substance to be brought to dark red-heat. otherwise the potassium and the sodium chlorides may be partly lost.

A small quantity of sodium is added to the sample. It is also advisable to use for the incineration of the substance a nickel crucible with the addition of sodium peroxide. After the incineration of the matter, chlorine is frequently determined by weight as silver chloride or after Volgard and Moor's method.

Delaville and Brown proposed to determine the chlorine content of blood by weighing after wet incineration by nitro-nitrous acid with $KMnO_4$ in a conical flask on a boiling water bath during 8—9 hours. M. P. Gapočko made use of this method in N. N. Ivanov's biochemical laboratory for determinations of chlorine in plants. N. N. Ivanov gives a favourable report of this method.

Chlorine, as is well known. does not enter as a component into any organic matter in plants. It may, therefore, be considered that the quantitative isolation of chlorine from plants is a simple task and requires but a very short time. A dry incineration of vegetable substances for the purpose of chlorine determination is justifiable only if other elements besides chlorine are to be determined in the ash obtained. But if chlorine alone is to be determined, it can be isolated from the plant in a simple manner.

On account of the great mobility of chlorine in plants there is likewise no reason for having recourse to an 8—9 hours wet incineration of vegetable matter as used by Delaville and Brown in their determinations of the chlorine content in blood, or by M. P. Gapočko in his analysis of the chlorine in plants. It seemed to us that by repeated treatement of comminuted plants with hot water the chlorine could be quantitatively isolated. If a nitric acid solution be used, chlorine can be isolated from plants in a very short time. The extraction of chlorine from plants can be accelerated by boiling the solution of nitric acid together with the sample on a burner or on a water bath. For the purpose of binding the liberated chlorine a titrated solution of $AgNO_3$ is added in excess to the nitric acid solution. Chlorine is determined be titrating (after Volgard's method) the excess of silver nitrate in the filtrate after the separation of the precipitate consisting of undestroyed vegetable matter and silver chloride.

For the determination of chlorine we took some oats, grown on a modified Helriegel mixture and ground in the usual manner on Excelsior mill, and also some clover from a field plot. Three series of experiments were made, in which were studied the influence of the duration of the action of the nitric acid and of the mixture of nitric-nitrous acid (HNO_3+NaNO_2) on the extraction of chlorine from plants, and also the effect of different degrees of heating the solution with the sample on a boiling water bath and on a burner. In addition, samples of different weight were treated with the acid for the same period of time, to determine the velocity of the extraction of chlorine from considerable samples, and not only from small ones.

Below are summarized the results of these analyses. The experiments were repeated with other substances and similar results were obtained.

I Series. Sample of vegetable mass of oats, 0.5 g.

Chlorine extracted with a $HNO_3+NaNO_2+AgNO_3$ mixture. Heating on a boiling water bath.

Acid mixture acting for	Percentage of chlorine in the plant
4 hours	1.38
2 »	1.38
30—45 min.	1.38

II Series. Sample of vegetable mass of oats, 0.5 g.

Chlorine extracted with a HNO_3+AgNO_3 solution. Solution heated on wire gauze at boiling temperature.

Acid acting for	Percentage of chlorine in the plant
2 hours	1.38
2 »	1.38
About 5 min.	0.67

III Series. Heated for 30 minutes on a boiling water bath; chlorine extracted with a HNO_3+AgNO_3 solution. Comminuted clover hay.

Sample of vegetable mass	Percentage of chlorine in the plant
0.5 g	1.29
2.0 »	1.30
5.0 »	1.32

The results of the above determinations of chlorine in plants permit the use of the following method of rapid chlorine determination in plants.

Sample of air-dried vegetable matter, from 0.5 to 5 g in weight, depending on the chlorine content of the plants is placed in a conical glass or Ehrlenmeyer flask of 200—250 ml 20—30 ml of HNO_3, sp. gravity 1.42, being poured over it. 30—35 ml of 0.1 n $AgNO_3$ are immediately added to the sample. The $AgNO_3$ solution must be added in excess, i. e. in about double the amount needed for binding all the chlorine contained. The flask with its contents is placed in a boiling water bath and kept there for 30—45 minutes.

During that time it is necessary thoroughly to stir the vegetable mass in the solution of nitric acid and $AgNO_3$ three or four times, using a glass rod. After the heating the flask is removed from the boiling bath and the solution is passed through an ordinary filter into a graduated flask of 250 ml. Upon filtration the residue on the filter is washed with distilled water, slightly acidified with a few drops of concentrated HNO_3 not containing any chlorine, to complete disappearance of any reaction to $AgNO_3$ (tested by diluted HCl). Thereafter, when the solution has cooled, the volume of the filtrate in the flask is brought to the mark. Two samples of 100 ml each are taken from the graduated flask and poured into glasses, 250—400 ml in volume, and the silver is titrated with ammonium thiocyanate of 0.1 or 0.01 n, according to the chlorine content in the plants, in the presence of 1—2 ml of ferric ammonium alum as indicator. When titrating $AgNO_3$ with ammonium thiocyanate it is necessary to add 1—2 ml of ether to the filtrate to accelerate the precipitation of the silver thiocyanate. The results of the titration are then referred to the entire volume of the filtrate: the difference between the $AgNO_3$ taken for the determination and the amount found during titration shows the quantity of silver bound up with the chlorine. The percentage of chlorine is then calculated after Volgard.

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GENETICS

INHERITANCE OF NICOTINE AND ANABASIN IN INTERSPECIFIC HYBRIDS WITH *NICOTIANA GLAUCA* GR.

By M. F. TERNOVSKIJ, M. I. KHMURA and N. I. ŽUKOV

(Communicated by N. I. Vavilov, Member of the Academy, 27. VII. 1937)

Systematic investigations of the alkaloid composition of species of the genus *Nicotiana* were commenced by Prof. A. A. Shmuk and his collaborators as early as in 1932. Those investigations have made it possible to identify several alkaloids others than nicotine in the composition of several *Nicotiana* species and, consequently, to attempt to study the alkaloid composition of plants produced by the hybridization of various species of the genus.

Among the representatives of the genus *Nicotiana* the South American species *N. glauca* occupies a special position owing to its morphology and biology (4), the peculiarities of its chromosomes (1, 2) and its chemistry. Among the chemical properties of this species are noteworthy the high content (up to 8%) of citric acid (6) and that of anabasin, an alkaloid not found in other representatives of this genus. The empirical formula of anabasin is the same as for nicotine, $C_{10}H_{14}N_2$. It is the product of condensation of pyridine and piperidine rings. The chemical specificity of *N. glauca* lends a special interest to the study of the inheritance of anabasin by hybrids of this species and the cultivated species of *Nicotiana*, i. e. tobacco and makhorka.

M. I. Khmura has proposed and elaborated a method of determining anabasin in the presence of nicotine.

The material for this investigation was F_1 of *N. tabacum* × *N. glauca* and the offspring of the prolific hybrids of *N. tabacum* × *N. glauca* obtained by M. F. Ternovski (3, 5) in 1932. The hybrids *N. rustica* × *N. glauca* were placed at our disposal by N. I. Žukov.

An analysis of hybrids of *N. tabacum* × *N. glauca* and the parent forms gave the following results.

Investigated forms	Number of specimens studied	Percentage of	
		Nicotine	Anabasin
N. tabacum (Dubek 24_{tt})	1	0.85	—
N. glauca (12_{gg})	1	—	0.60
F_1 *N. tabacum* (Samsun) × *N. glauca* ($24_t + 12_g$)	1	—	0.87
F_1 *N. tabacum* (Dubek) × *N. glauca* ($24_t + 12_g$)	1	—	0.83
F_1 *N. ditagla* ($24_{tt} + 12_{gg}$)	1	—	1.02
F_1 Sesquidiploid ($24_{tt} + 12_g$)	3	—	1.28
F_1 Sesquidiploid ($24_t + 12_g$)	3	—	0.55
F_1 *N. ditagla* × *N. sylvestris* ($24_t + 12_g + 12_s$)	1	—	0.83

The above data, confirmed by a number of other supplementary analyses, show a complete predominance of anabasin over nicotine in the investigated hybrids of *N. tabacum* × *N. glauca*, i. e. in the first generation: amphidiploid *N. ditagla*, sesquidiploid ($24_{tt}+12_g$), sesquidiploid (24_t+12_{gg}), and in the triple hybrid *N. tabacum* × *N glauca* × *N. sylvestris* ($24_t+12_g+12_s$). Of all the analyses made only in two cases there was observed in the sesquidiploid ($24_{tt}+12_g$) a faint opalescence on titrating the nicotine which may possibly point to the presence of quantitatively indeterminable traces of nicotine. In all the remaining cases there was a complete absence of any reaction to nicotine.

In *N. glauca* the quantity of anabasin does not exceed 0.6—0.8%; its content in the hybrids is, however, not infrequently considerably higher. The lowest content of anabasin was observed in sesquidiploids (24_t+12_{gg}); it was higher in the hybrids F_1 (24_t+12_g) and in the amphidiploid *N. ditagla* ($24_{tt}+12_{gg}$), and lastly, the highest anabasin content was found in the sesquidiploids with two genomes of tobacco and one genome of *N. glauca*. Thus, the increase in the proportion of tobacco chromosomes to *N. glauca* chromosomes is associated with an increase in anabasin content. This appears to indicate that in the presence of the *N. glauca* genome, the tobacco genes controlling the accumulation of nicotine, promote the production of corresponding amounts of anabasin. We thus observe a specific interaction of the genes of one species with those of another, leading to the conversion of one chemical substance, nicotine, into another closely related substance, anabasin.

24 plants of the succeeding generations (F_3, F_4, F_5 and F_6) of the sesquidiploid ($24_{tt}+12_g$) have been studied. In two cases no anabasin was discovered at all. In the remaining plants the content of anabasin showed great fluctuations, ranging from traces to 77% of the total amount of alkaloids. No plants were recorded having only anabasin and no nicotine. This fact is due not only to the insufficient number of analyses made, but also to the sesquidiploid ($24_{tt}+12_g$) being cytologically and genetically an unstable organism undergoing a formative process essentially tending to the elimination of the *N. glauca* chromosome and to the accumulation of tobacco type forms with 48 chromosomes (4). The variations in the content of nicotine and anabasin in the later generations of the sesquidiploid show that there exists one or more than one gene controlling the conversion of nicotine into anabasin. These genes may either be identical with those of anabasin or entirely different.

No nicotine whatever was discovered in any of the investigated hybrids (71 plants) of *N. rustica* × *N. glauca*. The three investigated sesquidiploid plants with one *N. rustica* genome and two *N. glauca* genomes gave results differing but slightly from the mean value of anabasin (0.46%) and showed a complete absence of nicotine. Unfortunately, no digenomous plants were studied. One plant, approaching the amphidiploid as to the number of chromosomes, gave 1.44% of anabasin. The maternal form of makhorka (Bakun Chernyi), cultivated under analogous conditions, had 0.83% of nicotine. The higher content of anabasin in the amphidiploid thus appears to be due to the conversion of the nicotine of the makhorka into anabasin. There is no precise correlation here. But preciseness could hardly be expected in view of the cytological instability of the amphidiploid at our disposal and of the possibility of interactions between the genomes, of a nature but little known to us.

The sesquidiploid of *N. rustica* × *N. glauca* (24_r+12_{gg}) is autosterile. The plants resulting from back and triple crossings were, therefore, studied. The analyses of this combination are summarized in the following table.

Hybrid combinations	Number of plants studied	Content of anabasin in percentages		
		Mean	Minimum	Maximum
Unstable amphidiploid	1	1.44	—	—
Sesquidiploid ($24_{\gamma} + 12_{gg}$)	3	0.46	0.41	0.50
Sesquidiploid × *N. glauca*	36	0.74	0.24	1.25
(Sesquidiploid × *N. glauca*) × *N. glauca* . . .	19	0.87	0.47	1.46
Sesquidiploid × *N. tabacum*	12	0.52	0.27	0.86

All the combinations in the above table show a complete absence of nicotine. The progeny of back and triple crossings gives, as regards anabasin content, a considerable segregation, which can be wholly explained by the cytological instability of that hybrid.

The data of this paper, establishing the conversion of nicotine into anabasin in hybrids of *N. tabacum* × *N. glauca* and of *N. rustica* × *N. glauca*, justify the initiation of more detailed studies of the inheritance of anabasin and nicotine, as well as attempts at breeding tobacco and makhorka forms possessing a new alkaloid foreign to these species. This latter subject is especially interesting in view of the high toxicity of anabasin used as an insecticide.

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AGROPHYSIOLOGY

SOIL TEMPERATURE AND THE EFFECT OF FERTILIZERS ON THE YIELD AND QUALITY OF SPRING WHEAT

By V. V. BUTKEVIČ

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Experiments of preceding years carried out with spring wheat in the laboratory of Academician D. N. Prianišnikov have determined the extent, to which the absolute and relative effect exerted on this plant by various fertilizers is controlled by environment factors such as soil humidity and dry winds if acting at different stages of development of the plant, and have also shown the results obtained by the supplementary feeding of the plant under the above conditions and in the different periods of its development.

These experiments have shown in the majority of cases that a dry wind lowered the percentage of nitrogen and protein in wheat grains. And only a slight but prolonged action of dry winds increases the content of protein and nitrogen in the grain if there is comparatively little nitrogen in the soil.

In 1936 we continued our investigations of spring wheat in collaboration with V. S. Šumakov, for the purpose of determining the effect of fertilizers on this plant as affected by temperature and, vice versa, the effect of temperature on wheat as affected by mineral nutrition.

By cooling the soil with water in double-walled vessels and by heating it with electric heaters we obtained three temperatures, namely, 20, 25 and 35° C. The soil for these experiments was the podzolized loam of the experimental plot of the Timiriasev Agricultural Academy.

The experiments showed that on unfertilized soil a rise in temperature to the maximum indicated raises the yield of grain. This increase in yield is especially marked when PK are added to the soil. The rise in temperature to 35° C produced, however, the contrary effect when nitrogen was introduced into the soil, especially if there was a lack of phosphorus.

In confirmation of the above we may quote the following data:

Experimental scheme	Yield of grain per vessel at temperature 20°C	25°C	35°C
1. Without fertilizers .	3.36	3.62	4.43
2. PK	2.87	3.61	5.46
3. NK	3.99	4.09	0.79
4. NP	10.31	9.76	6.64
5. NPK	11.63	9.52	7.31

The increase in the percentage of nitrogen and protein with rise in temperature is illustrated by the following figures:

Fertilization scheme	Percentage of total nitrogen			Percentage of protein nitrogen			Percentage of non-protein nitrogen		
	20°C	25°C	35°C	20°C	25°C	35°C	20C°	25°C	35°C
1. Without fertilizers .	2.14	2.30	2.73	1.67	1.97	2.42	0.46	0.33	0.30
2. NPK	3.22	3.42	3.35	2.66	2.83	3.15	0.55	0.59	0.19

Fertilization neutralized somewhat the effect of the rise in temperature on the accumulation of nitrogen in plants. As regards protein nitrogen, however, the role of temperature remains sufficiently distinct.

The percentage of phosphorus in the grains decreases somewhat with the rise of soil temperature; this fall being especially marked in the nitrogen variant.

The data obtained are important in elaborating measures for rising the quality of wheat grain, and also in determining the causes of the drop in the percentage of protein in the wheat grains if crops are shifted from the south-east to the north-west of the European part of the USSR. It is noteworthy that with the rise of soil temperature the duration of the vegetative period decreases, this decrease being especially marked in the NK variant (18 days less).

To ascertain the cause of the rise in the percentage of nitrogen and protein in wheat grain with the rise in temperature, a series of supplementary experiments was carried out.

The purpose of the experiments with wheat seedlings was to discover, how the temperature of the nutrient solution influences the rate of absorption by the plants of phosphorus and of nitrogen out of nitrates and ammoniates (within the limits of the temperature studied, namely from 10 to 41° C). These experiments have shown that the optimum for the absorption of salts fluctuates within the limits approaching 23—25 °C, which is followed by changes in the relative velocity of absorption by the plants of ammonia and nitrates. With a rise in temperature above 15° C the ammonium nitrate is converted in the course of experiment from a physiologically acid, into a physiologically alkaline salt.

Experiments with soil (without plants), made at various temperatures, have demonstrated that not only the optimum for nitrification but likewise that for the amount of hydrolizable nitrogen (determined after Turin) lies close to 35° C. The maximum values of nitrates and of hydrolizable nitrogen occurred at 35° C both in the unfertilized and in the NPK variant.

At a mean temperature of about 25° C, the quantity of water-soluble phosphoric acid decreased. This is, apparently, associated with its biological fixation in the soil. This must have led to a fall in the absorption of phosphorus by the plants and to a relatively high accumulation of nitrogen in the grain.

An analysis of water extracts taken from the soil at different temperatures showed that with a rise in temperature we not only have a change in mobilization of the nutrient substances of the soil under the effect of biological factors, but also an increase in their solubility; namely, a rise in the temperature of the soil or of its aqueous extract greatly increases the amount of organic matter and phosphoric acid extracted from the soil.

The vegetative experiments were accompanied by measurements of transpiration, which prove that the efficiency of water utilization is intim-

ately connected with soil temperature and fertilization. This efficiency increases with a rise in temperature, except in the NK variant.

The results obtained have a direct bearing on the elaboration of rational methods of supplementary feeding of field crops with mineral fertilizers. These methods of controlling plants during their vegetative period are spreading in the USSR. An insufficient consideration of a number of associated conditions causes disappointment in many people, who were till quite recently full of enthousiasm for this new measure. In a number of cases supplementary feeding must be accompanied by other measures, and in the first place, by a sufficient moistening of the soil; besides it must not be regarded as a substitute for the main charging of the soils with fertilizers. Soil humidity and soil temperature are intimately connected. The present paper shows with sufficient clarity the relationship between the temperature of the soil and the effectiveness of the fertilizers. This dependence must be taken into account in the complex of measures for increasing the yield and raising its quality, as, for instance, in the choice of the manner of introducing the fertilizers (this mainly refers to nitrogen fertilizers), in the dates of their introduction, etc. The data obtained, by indicating the trend of the temperature effect in individual cases of the application of mineral fertilizers, confirm the principle that supplementary feeding must be correlated not only with the phases of development of the plants, but also with other conditions, in particular with meteorological factors, the general importance of which needs no proofs. Besides, both in supplementary feeding and in the main introduction of fertilizers, it is not sufficient to be guided only by the chemical analysis of the soil and by our knowledge of the very approximate requirements of cultivated crops in the various elements of mineral nutrition. Both in agricultural practice and in scientific research work, much more attention must be paid to environmental conditions, which cannot be directly determined by the character of the soil. Investigations of such a nature are not only interesting from the standpoint of determining the optimum conditions for the fertilizer to give effect, but also from the standpoint of the general measures to be taken for bettering the general environmental conditions controlling the yield and its quality.

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PLANT PHYSIOLOGY

EFFECT OF HETEROAUXIN IN THE ROOTAGE OF CUTTINGS FROM SUBTROPICAL WOOD

By M. M. GOČOLAŠVILI and N. A. MAXIMOV, Corresponding Member of the Academy of Sciences

J. Loeb (1) was the first to suggest that hormones play a part in the rootage of cuttings. This was later fully confirmed by the works of Bouillenne and Went (2,3). The hormonal nature of this phenomenon was also clearly demonstrated by Eremeev's (4) experiments carried out in consultation with one of us (N. A. Maximov). In recent years a new light has been cast on this problem by the works of Laibach (5) and those of Zimmerman, Wilcoxon and Hitchcock (6) of the Boyce Thompson Institute. These writers have shown that the artificial introduction of plant hormones—auxin and heteroauxin—and likewise of a number of synthetic substances (indole-oleic, naphthalene-acetic, anthracene-acetic, and other acids) also accelerates rootage and increases the striking of roots by cuttings. Hormones or synthetic substances may be introduced either by the temporary immersion of the cuttings in strongly diluted aqueous solutions of these substances or by coating them with lanoline cream containing a small quantity of the hormone.

As the possibility of propagating, by means of cuttings, many subtropical woody species, the cuttings of which root with great difficulty or do not root at all, would be of great practical importance, we decided to study the effect of treating them with heteroauxin (β-indole-acetic acid). A chemically pure preparation of heteroauxin was received by us from D-r R. Manske, Chemist of the National Research Board, Canada. We avail ourselves of this occasion to once more express our gratitude to him.

The main objects of our experiments were cuttings of the trifoliate orange (*Poncirus trifoliata*) and the Unshiu Tangerine orange (*Citrus Unshiu*). With the usual methods of cultivation, former root very slowly and with great difficulty whilst the latter do not root at all.

As regards the application of heteroauxin for the rootage of cuttings from citrus trees, we had up till now only the experiments of Cooper (7) who obtained by means of the lanoline method an increased root growth in the cuttings from the lemon tree. But lemon tree cuttings are generally known to root fairly easily. We started our experiments in December, 1936. The cuttings of poncirus, when taken, were practically lignified, some of them (about one third) having already shed their leaves. The diameter of the cuttings ranged from 0.2 to 0.4 cm. The Tangerine tree cuttings were in a similar state. The treatment with heteroauxin was effected by immersing the lower part of the cutting in dilute aqueous solution (1 : 2500 and 1 : 5000) of that substance. In view of the extremely low solubility of hetero-

auxin in water, we followed Hitchcock and Zimmerman's example and previously dissolved it in several cubic centimeters of alcohol, whereafter the alcohol was diluted with water to the required concentration.

Control cuttings were immersed for a similar period of time in water containing the same amount of alcohol as the above solution. The duration of treatment ranged from 1 to 5 days. After treatment the cuttings were planted in a hot house in a mixture of equal volumes of sand and peat-moss.

The experiments with the poncirus cuttings (Table 1) proved the full possibility of their hundred per cent rootage within the comparatively short time of 30—45 days. And this in spite of the fact that this plant is one of those that are difficult to propagate by cuttings.

Table 1

Effect of Heteroauxin on the Rootage of Poncirus Cuttings

No of variant	Heteroauxin concentration	Duration of treatment in days	Percentage of cuttings rooted		
			In 15 days	In 30 days	In 45 days
1	1 : 2500	1	70	85	100
2	1 : 2500	3	13	73	80
3	1 : 2500	5	6	50	62
4	1 : 5000	1	50	100	—
5	1 : 5000	3	38	75	100
6	1 : 5000	5	8	50	58
7	Control	3	0	0	5

Thus Elenev ([8]), for instance, employed over ten different methods for the purpose of accelerating root growth in poncirus cuttings. And of the approximately two and a half thousand cuttings tested he obtained an average rootage of 2.04%, the highest percentage being 24. Besides, the rootage of these cuttings usually require 3—4 months and more. A rapid hundred per cent rootage of the poncirus cuttings has been attained for the first time in our experiments.

The most rapid all round rootage was obtained in the 4th variant by a short treatment (24 hours) with a weaker concentration of heteroauxin (1 : 5000). A longer action both of this and of a stronger concentration produced a toxic effect—the cuttings were slower to root and manifested signs of rotting.

A short treatment with a stronger concentration (1 : 2500) also gave a hundred per cent rootage, but progressed rapidly.

It is noteworthy that those cuttings, which had not shed their leaves, showed a more rapid rootage. The same phenomenon had also been recorded by Cooper ([7]) and by Hitchcock and Zimmerman ([6]). It would appear that root formation requires in addition to its specific hormone, also certain other substances furnished by the leaves. Possibly, we have to deal with some substances synthesized in the leaves during the process of assimilation [Went ([9])].

Treatment with heteroauxin also increased the number of roots. Whilst in successful cases of rootage by common methods only single roots are obtained, the average number of roots in our experiments was 10 to a cutting, and in individual cases the number rose to 14—16 vigorous roots (Fig. 1).

We shall now pass on to our experiments with the rootage of cuttings from the Unshiu Tangerin orange.

As is known, all attempts of rooting the tangerine tree cuttings have been unsuccessful. Our experiments have likewise shown the absence of rootage in the control cuttings. Even the rooting of the Tangerine cuttings treated with

heteroauxin proceeds with much greater difficulty than that of poncirus cuttings (Table 2).

The highest percentage (31%) of rootage of Unshiu Tangerine cuttings was obtained after treatment with a heteroauxin solution of 1 : 2500 concentration during 3 days. A longer treatment with the same solution led to a rotting of the cuttings. A weaker concentration (1 : 5000) produced a weaker effect; the percentage of rootage not rising above 13—17 per cent.

Table 2

Effect of Heteroauxin in the Rootage of Cuttings from the Unshiu Tangerine orange (Winter Experiments)

No of variant	Heteroauxin concentration	Duration of treatment in days	Percentage of cuttings rooted	
			In 1.5 months	In 2 months
1	1 : 2000	1	—	18
2	1 : 2000	2	—	12
3	1 : 2000	3	8	31
4	1 : 2000	4	—	—
5	1 : 2000	5	—	—
6	1 : 5000	1	—	—
7	1 : 5000	2	—	7
8	1 : 5000	3	6	13
9	1 : 5000	4	—	13
10	1 : 5000	5	15	17
11	Control	—	—	—

A more difficult rootage of the Unshiu Tangerine cuttings as compared with that of the poncirus cuttings is correlated with a lesser number of roots developing on each cutting in the former case (Fig. 2).

As cuttings root better in spring than in winter, the experiments, were repeated in the spring of 1937. Green cuttings were taken from the Unshiu Tangerine tree at the beginning of April and treated with heteroauxin solutions of different concentrations. In two months' time the following results were recorded (Table 3).

Fig. 1. Cuttings of *Poncirus trifoliata*. Right—control, left—plants treated with heteroauxin solution (1:5000 during 24 hours).

Fig. 2. Cuttings of the Tangerine tree. Right—control; left—plants treated with heteroauxin solution (1:2500 for 3 days, 24 hours).

Table 3

Effect of Heteroauxin on the Rootage of Unshiu Tangerine Cuttings (Spring Experiments)

No of variant	Age of cuttings	Heteroauxin concentration	Duration of treatment in hours	Percentage of cuttings rooted in 2 months
1	Green cuttings of autumn growth (apices)	1 : 2500	12	70
2		1 : 2500	18	50
3		Control	12	0
4	Green cuttings but more lignified	1 : 10000	48	50
5		1 : 5000	48	50
6		1 : 2500	30	50
7		1 : 2000	24	50
8		Control	24	0

The experiments are still continuing and the percentage of cuttings rooted is shown only approximately. Our presumption that rootage must proceed much easier in spring was fully confirmed and we succeeded in obtaining up to 50 per cent, and in one case even up to 70 per cent rootage of Unshiu Tangerine cuttings. The problem of the propagation by means of cuttings of this plant which roots with such difficulty may now be considered practically solved.

We also started experiments for determining the effect of heteroauxin on the rootage of cuttings from the tung tree (*Aleurites Fordii*) and also from other subtropical trees. These experiments are not yet finished. We shall, therefore, restrict ourselves to the statement that here likewise the results obtained by us were positive.

All the above experiments clearly show that heteroauxin is a substance which may be applied to good advantage in horticultural practice. It would, therefore, be most desirable that the synthetic production of heteroauxin should also be begun in our Union.

Summarizing the results of our reconnoitring experiments, we arrive at the following conclusions:

1. We have succeeded in obtaining by treatment with weak solutions of heteroauxin (β-indole-oleic acid) a 100 per cent rootage of the cuttings from the trifoliate orange (*Poncirus trifoliata*) and up to 50—70 per cent rootage of Unshiu Tangerine (*Citrus Unshiu*) cuttings, whilst, without such treatment the cuttings of these plants either did not root at all or rooted but very rarely.

2. The action of heteroauxin is much stronger on leafy cuttings than on cuttings that have no leaves. This indicates that the substances elaborated in the leaves play an important part in the formation of roots.

3. This is further supported by the fact that under the effect of heteroauxin green Tangerine cuttings root better in spring, when the conditions for the functioning of the leaves are more favourable than in winter, when assimilation is depressed.

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PLANT PHYSIOLOGY

ACCELERATION OF THE GROWTH OF SEEDLINGS AND THE ACCUMULATION OF BLASTANIN IN THE ENDOSPERM THROUGH THE YAROVIZATION OF SPRING AND WINTER WHEATS

By A. SEREISKIJ and M. SLUDSKAJA

(Communicated by A. A. Richter, Member of the Academy, 25. VII. 1937)

We have already had occasion of indicating the difference which appears between the behaviour of yarovized and that of unyarovized wheat plants from the first days of their growth ([1], [2]).

The seedlings of wheat varieties, possessing winter qualities to a noticeable extent, show, as a rule, quicker rates of growth and of leaf development

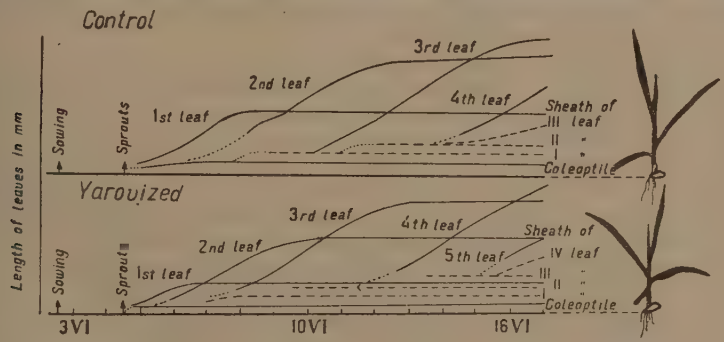

Fig. 1. Scheme of Development of «Novokrymka 0204» Seedlings.

when yarovized than the corresponding controls, even when the control seeds are soaked before planting and brought to the same stage of germination as the yarovized seeds.

The above is best proved by a detailed analysis of the rate growth, as, for instance, by the graphic method illustrated by Fig. 1. This graph has been plotted on the basis of the mean results, obtained for plants of Novokrymka 0204. These plants were sown on the same day and cultivated under entirely similar and constant conditions; the behaviour within each variant being sufficiently uniform.

A comparison of the curves shows that although the preliminarily soaked controls sprouted 8 hours earlier than the yarovized seeds, the latter overtook them noticeably within the first 24 hours and were already producing their second leaf, while the first leaf in the controls had not yet completed the

initial phase of growth. In 72 hours the first leaf of the yarovized plants had already completed its growth and the leaf-blade inclined downwards; the second leaf had attained half its ultimate length and a third leaf was already appearing from out of the sheath formed by the second. In the control the first leaf had by that time only passed into its last stage of growth, and the second was only in its initial phase; a third was yet far from appearing. The duration of growth of the first leaf (from its emergence from the coleoptile till cessation of growth) in this experiment was 62 hours in the controls and only 50 hours in the yarovized plants; correspondingly the duration of growth of the second leaf was 136 hours in the controls and only 98 hours in the yarovized plant, etc. The plants figured in the scale of the graph give an idea of the differences in their development at the time of the last measurements.

A number of facts compel us to assume that the correlation between the observed phenomenon and yarovization is not a fortuitous one. Noticeable improvements in the rates of development of the seedlings only appear when the seeds have been previously kept in moisture and temperature conditions required by yarovization. If the seeds are imperfectly soaked or if the soaked seeds are kept in warmth (at 20—24° C) the results obtained are always negative: either complete death of the plant or a stunted growth and development. In the latter case, the development of the coleoptile and of the first and second leaf is especially slow. Elements of depression of various morphological parts may also occur in yarovized plants; but as compared with the general acceleration of the rates of development, these elements are of secondary importance here and usually manifest themselves only in a certain shortening of the blade of the first leaf. They only become more marked when the soaked seeds are kept under such conditions for a much longer time than required for the completion of yarovization.

In such varieties, as Novokrymka 0204, Kooperatorka 0194, Ferrugineum 1316/2, the acceleration in the rates of differentiation is still quite noticeable after 35—50 days of yarovization, while no depression of separate elements is as yet observed with the exception of the shortened blade of the first leaf. The acceleration is much less marked after such a prolonged yarovization treatment of spring forms of the Hordeiforme 1872 or Kochin's Arnautka type. The early varieties, Garnet and Novinka, showed a complete absence of any difference or even a retardation in the rate of differentiation.

The above described «morphological response» has even repeatedly served as a means of diagnosing the degree of yarovization of 4—5 day-old seedlings. In one of our experiments of 1933, in which the interaction between winter and spring varieties was being studied(3), we had 8 variants of Ferrugineum 1316/2 seeds, which had been treated by yarovization, and 8 variants which had not been specially yarovized. All the variants had been preliminarily ciphered and then diagnosed according to their seedlings. The results fully agreed with the initial data with only one exception. This «unyarovized variant», which gave a positive response to yarovization, continued subsequently to behave in an unusual manner and eared later than the specially yarovized plants, but much earlier than all the others. In another experiment with the winter variety Novokrymka 0204, the seeds planted had been yarovized for 50, 34, 23 and 15 days respectively, while the control seeds had been kept in a soaked state at 16—20° C for 5—3 days before sowing. An unmistakable positive «morphological response» to yarovization was shown by the 50-day variant, a less obvious one by the 34-day variant. All the others gave a negative response. And, in accordance with the above all the 15 plants of the 50-day variant eared in due time (in two months'time); whilst part of the 34-day variant eared with a considerable retardation (of almost a month) and,

part of the plants of latter variant did not develop beyond the tillering stage. All the other variants failed to reach even the shooting stage.

The most reliable diagnosis is obtained by comparing a series of curves for the first, second and third leaves—growth graphs, as shown in the example above, and not by comparing separate morphological elements, for instance, the first leaf, with their ultimate size.

It is, however, necessary to use the utmost caution in all such methods of diagnosis so long as the nature of the relationship between the response used for diagnosing and yarovization itself remains unknown.

On the basis of certain of our former observations of 1934—1935, taken in conjuction with the recent statements made by academician N. G. Kholodnyj ([4],[5],[6]) on the possibility of the accumulation of an active growth-promoting substance of the type of blastanin as a result of yarovization, we have attempted to correlate the run of the above-described «morphological response» with the process of accumulation of the above-indicated substance in the endosperm of the seeds of the spring wheat Novinka and the winter variety Erythrospermum 917.

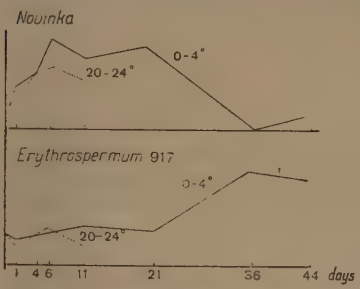

Fig. 2. Variations of Blastanin Content in the Endosperm of Wheat.

In the main experiment, part of the uniformly soaked material brought to the stage of germination was kept at 2—4°C and part at 22—24°C. Samples for analyses for hormone and for growth were taken on the day of soaking (control) and in 1, 4, 6, 11, 21, 36 and 44 days. The first (control) determination was again repeated at the end of the experiment.

For determinations of blastanin a slice of endosperm was each time taken from 7—8 wheat seeds of each variant. These slices of endosperm were fixed unilaterally on decapitated coleoptiles of Pobeda oats. The angle of inclination was measured 4 and 8 hours later (the necessity of such prolonged determinations had been shown by preliminary experiments).

The results of the experiment are graphically represented in Fig. 2. Determinations of the warm variant could only be brought up to the eleventh day, as moderately soaked seeds if kept at that temperature for a longer time were apt to undergo pathological modifications.

The graph shows that the content of blastanin in the wheat seeds—which is originally very low (deviation of the coleoptiles 3°—4°)—actually increases by degrees if they are kept under conditions of «seed material». In the Novinka variety this increase occurs comparatively rapidly, and quicker in the cold than in the warmth; the maximum being attained on the sixth day. Starting approximately with the 20th day of yarovization the amount of blastanin in the endosperm begins to decrease, dropping almost to zero by the 36th day. In Erythrospermum 917 a noticeable increase in blastanin content only occurs somewhat between the 21st and 36th day of yarovization. The difference between the warm and cold variants begins to become noticeable on the 11th day.

The shift in the rates of growth and differentiation of seedlings of Novinka occurs much earlier than in those of Erythrospermum 917. This is in agreement with the data on the accumulation of the growth-promoting substance. The most marked difference as regards Novinka is observed between the growth-curves of seedlings from samples taken on the 6th and 11th days of yarovization.

The growth-curves of seedlings from corresponding samples of the warm variant of the same variety show no essential differences. The curves of control samples planted both at the beginning and at the end of the experiment for checking the uniformity of the conditions, almost coincide with one another.

In Erythrospermum 917 an essential acceleration in the rates of growth occurs approximately at one time with the commencement of the rise in the curve of accumulation of blastanin, i. e., only on the 21st day.

These data do not as yet justify any inference as to the decisive role of growth-promoting substance in the process of yarovization itself considered as a stage of development in the sense of Lyssenko. May be, the marked activation of the reserve of blastanin is an indirect consequence of some other process occurring during yarovization. The presumption of a connection between the «morphological response»—i. e., the accelerated development of seedlings due to yarovization—and the accumulation of growth-promoting substances however is fully confirmed.

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PLANT PHYSIOLOGY

THE PERIODS OF ABSORPTION OF NUTRIENT SUBSTANCES BY THE SUNFLOWER PLANT IN CONNECTION WITH SUPPLEMENTARY FEEDING

By T. T. DEMIDENKO and V. P. POPOV

(Communicated by A. A. Richter, Member of the Academy, 31. VII. 1937)

Under natural conditions, the concentration of soil solution depends on the humidity of the soil and on the content of salts, the amount of which can be supplemented by fertilization. When the humidity of the soil is an optimum one, the development of the plant proceeds favourably enough even at high concentrations of the salts of the soil solution. When humidity drops, the concentration of salts rises and the growth of the plant begins to slow down. In view of the above, the nutrient substances, introduced under the plant in agricultural practice, frequently give less effect in arid than in humid years, when they enter more readily into chemical reaction with the absorbing soil complex.

During their vegetative life plants consume considerable amounts of nutrient substances. These latter, when introduced into the soil, must be utilized as economically as possible, giving a maximum of yield per unit of nutrient substances introduced. The utilization of mineral elements proceeds most rationally when their concentrations in the soil are low and when they are introduced in a definite sequence in accordance with the specific effect of each element in biochemical reactions. The leading elements in the life of plants are nitrogen, phosphorus and potassium.

The main carrier of the life functions of plants is the protoplasm, which includes in its composition proteins mainly synthesized at the expense of nitrogen and products of assimilation. The increase of the protein mass and the formation of new protein structures, identical with the old ones, continues incessantly in the plant organism during its growth.

In addition to nitrogen which is an active participant in the synthesis of proteins, phosphorus is also one of the most important elements in protein synthesis, as it enters into the composition of complex nucleic protein compounds.

Side by side with the above two elements, potassium likewise actively participates in the synthesis of proteins and in the transportation of carbohydrates. Those plants which accumulate considerable amounts of carbohydrates and fats in their organs, usually absorb a large quantity of this latter element which has radioactive properties and emits β - and γ-rays.

According to the theory of Academician V. I. Vernadsky [1] the elements entering into the composition of living matter are pure elements, i. e., they

consist of only one isotope and not of a mixture of isotopes, whilst we have in the surrounding nature a mixture of different forms of the chemical element. The isotopes of living matter or biotopes must not only be distinguished by their atomic weight, but also by a greater intensity of their radioactive disintegration.

It is possible that living organisms possess the power of selecting definite isotopes out of mixtures in the same manner as they are able to select certain chemical elements out of the surrounding medium. If the nutrient medium contains a mixture of potassium isotopes of atomic weight 39 and 40, and if there are only some hundredths of one percent of the latter isotope in the mixture, nevertheless on the passage of the mixture through the organism, isotope 40 will be retained by the organism, whilst isotope 39 will be deposited at points where it will be accumulated in superabundance as an unneeded element.

As potassium plays an active part in the transportation of carbohydrates from the green leaf to the points of its storage, those plants which accumulate large quantities of carbohydrates absorb much potassium, especially during the period of a vigorous formation of assimilates. As the soil solution contains but little active potassium which actively participates in photosynthesis, the plants have to absorb large amounts of it during the increased activities of the green leaf. When intoducing nutrient substance into the soil in agriculture, the object aimed at is to obtain a good crop with an insignificant expenditure of mineral fertilizers.

A number of investigators, introducing nutrient substances at different dates, observed that their utilization by the plants was also different ([2],[3],[4],[5]).

Supplementary «feeding» is now widely used in agriculture as a method of obtaining abundant crops. Some points of this vast problem have, however, been but slightly studied up to present. This is no doubt the reason why the introduced fertilizers are less efficiently utilized by the plants than would be the case if it were possible to determine strictly, what substances the plants need for their development and when.

In the Soviet Union, sunflower fields occupy huge areas, but the absorption of nutrition by the sunflower plant through its roots has been very little studied as yet. Liudogovskij, Konovalov and Tulaikov ([6],[7],[8]) have investigated the ash composition of this plant and have shown that the sunflower absorbs considerable quantities of potassium, less calcium and but very little magnesium. As to the amount of phosphoric acid absorbed by the sunflower during its vegetation, and that of sulphuric acid, it is difficult to establish strict relationship between these nutrient substances, for the results obtained by various authors do not give an identical picture, these authors having worked with different varieties cultivated on diverse kinds of soil.

Studying the dynamics of the absorption of ash elements and nitrogen by the sunflower during the vegetative period, Čižov ([9]) has found that, during the growth of the plant, this dynamics has two maxima, characteristic for the physiology of its root nutrition: the first occurring at the beginning of flowering and the second before ripening.

In his comparatively detailed work Ivanov ([10]) shows that the absolute content of nitrogen in the plant as a whole and in the seeds gradually increases and reaches its maximum 10 to 15 days before harvesting. The maximum accumulation of nitrogen in the leaves, stems and heads occurs at various dates, mainly before and after flowering. As regards ash content, the maximum value is reached 15—20 days before the ripening of the sunflower.

For the purpose of determining the periods of absorption of the nutrient substances by the sunflower we carried out vegetative experiments with soil and sand cultures. The results are summarized in the table.

Scheme	Weight of			
	total mass		seed	
	Grams	Percentage	Grams	Percentage
Control: Soil without fertilizers	75	100	12	100
I. Full dose at the commencement of the test				
P	100	133.3	15.5	125.8
N	103	137.3	20.5	178.3
PN	105	140.0	25.4	211.6
PNK	107	142.1	30.0	250.0
II. Full dose on sprouting				
P	125	166.5	19.0	168.2
N	136	181.3	22.0	183.3
PN	140	186.6	31.0	258.3
PNK	207	277.0	36.0	300.0
III. Full dose at the beginning of the formation of the head				
P	86	114.6	15.0	125.0
N	112	149.3	22.0	183.3
PN	124	165.3	25.0	208.3
PNK	140	186.6	26.0	216.6
IV. Full dose during flowering				
P	85	113.3	12.2	100.9
N	90	120.0	12.5	104.1
PN	93	124.0	12.6	105.0
PNK	95	126.6	13.0	108.3
V. Half a dose at the commencement of the test				
P	75	100.6	12.0	100.0
N	90	120.0	17.5	145.8
PN	97	129.3	20.0	166.6
PNK	108.5	144.0	23.0	191.6
VI. Half a dose during flowering				
P	77	120.6	12.0	100.0
N	81	108.0	12.8	106.6
PN	86	114.6	12.8	106.6
PNK	94	124.7	13.0	108.3
Control: Original Belousov mixture	82.8	100.0	15.6	100.0
N during 2 periods	85.4	104.3	17.2	110.2
N » 3 »	94.6	114.2	16.5	105.7
PK » 2 »	80.0	96.6	14.8	94.8
PK » 3 »	77.2	93.2	13.4	85.8
PNK » 2 »	88.6	107.0	18.6	119.2
PNK » 3 »	75.8	91.5	17.0	108.9
Control: Modified Belousov Mixture	80.2	100.0	16.6	100.0
P during 2 periods	89.4	111.4	18.5	111.4
P » 3 »	80.2	100.0	19.8	119.2
K » 2 »	80.0	99.7	20.4	122.8
K » 3 »	78.8	98.2	23.2	139.7
NP » 2 »	85.0	105.9	21.4	128.9
NP » 3 »	82.4	102.7	20.2	121.6
NK » 2 »	75.5	94.1	23.6	142.1
NK » 3 »	72.2	90.0	22.3	134.3

In soil cultures the fertilizers were introduced as $(NH_4)_2SO_4$, KCl and $Ca(H_2PO_4)_2$ at the rate 0.15 g of the agent per 1 kg of absolutely dry soil (vessels of 10 kg each).

The soil used was taken from the thick black-earth layer of the Voronezh Regional Experimental Station. The nutrient substances were introduced as chemically pure salts. The sunflower cultivated was the Fuksinka № 3 variety, bred by the Voronezh Province Experimental Station and resistant to broomrape.

In sand cultures, Belousov's mixture was used. To study P and K separately we used our own modification of that mixture, where P was introduced as $Ca(H_2PO_4)_2$ and K as KCl.

In the tests with both soil and sand grown plants, unquestionably good effects were obtained by introducing part of the nutrient substances during the period of vegetation, the increase in the amount of seed (as compared with the controls) becoming fairly noticeable in the experiments of 1935 (soil cultures) somewhat later, i. e., during the second period, from the time of sprouting to the beginning of the formation of the head.

Potassium produces a greater effect on the seed during the second period. The same with phosphorus. As for nitrogen, its positive effects are felt, not only during the second, but also later, during the third period, i. e., after the head has begun to form.

The increase in the total vegetative mass of the plant in those experiments followed a similar course.

The experiments of 1936 with sand cultures showed that the effect of nitrogen on the seed is greatest during the second, and partly during the third period; phosphorus produces an increase of +11.4% during the second period, and of +19.2% during the third. Potassium was found to be very effective both during the second (22.8%) and in the third (+39.7%) period.

As regards total vegetative mass, the highest effect was obtained with nitrogen (during the second period).

On the basis of the above data collected for two years, we thus arrive at the following conclusions:

1. The sunflower plant stores up nitrogen most vigorously during the second and the third period, i. e., up to the formation of the head and for some time after that. In view of the above, nitrogen produces the greatest effect when introduced during these periods.

2. The sunflower plant stores up phosphorus and potassium during the period from sprouting till the formation of the head, and consequently their introduction during that time gives the best results.

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PLANT PHYSIOLOGY

THE INFLUENCE OF DAILY INTRODUCTIONS OF N AND P ON THE STORING-UP OF HYDROPHILE COLLOIDS IN THE SUGAR BEET

By V. P. POPOV

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The main fact to bee taken into account in studying the influence of low concentrations of nutrient substances on the development and the chemical composition of beetroot is that a high dosage of nutrient substances results in a higher concentration of the soil solution, which retards the development of plants at its early stages, while, on the other hand, high concentrations and one-sided nutrition in the later half of the vegetation period may contribute to the accumulation of large amounts of soluble (harmful) nitrogen in the root ([1—5]).

In the case of black earth soils, with their rather low nitrifying power and the rapid retrogradation of P_2O_5, the study of low concentrations is of great practical importance in matters concerning the radical nutrition of the sugar beet ([6—8]).

This paper is the result of such a study of the influence of low concentrations of N and P both on the plant (sugar beet) itself and on its colloidal-chemical composition.

To guard against the extraneous influences of the absorbed soil complex and of the reactions of exchange (in the soil), this series of experiments was made on sandy soils.

At the beginning of vegetation, the plants were grown on half ration of the element under consideration (N, P or NP), in Belousov's mixture as modified by the writers, and, upon the appearance of 5—6 pairs of fully-developed leaves, began the fractional introduction of the elements under consideration. The introductions were made:

1. Daily . . . . . 56 times
2. Every other day . . . . . 27 »
3. Once in five days . . . . . 13 »
4. Once in ten days . . . . . 7 »

Sowing 3rd June; harvesting 20th October

The results are shown in the Table.

The introductions of nitrogen caused a steady rise in the coefficient of colloidality (K) of the sugar beet (from 13.06 to 15.08), starting from the less frequent introductions (7 in all) and ending with the more frequent ones (56 in all). Since the total amount of nitrogen introduced during the vegetation period was the same in every case, the following relation may be established between the coefficient of colloidality, the dosage and the frequency of introductions, viz.: 1) The more frequent the introductions of nitrogen and the lower its concentration, the higher is K. 2) The less frequent the introductions of nitrogen and the higher its concentration, the lower is K.

Scheme	Weight of root		Percentage of sugar	Coefficient of colloidality	Viscosity of sap	Surface tension	Content in the root, in %		
	g	%					Total N	P_2O_5	Soluble N
Control modific.	352	100	17.2	13.69	2.154	69.1	0.8838	0.5757	0.2440
N introduced 7 times .	440	125.0	20.0	13.06	3.396	61.8	0.4787	0.5281	0.2793
N » 13 » .	363	103.1	19.0	13.53	3.171	63.1	0.5970	0.4512	0.2655
N » 27 » .	298	84.6	18.6	14.34	3.076	63.9	0.9287	0.4791	0.2351
N » 56 » .	297	84.3	18.1	15.08	2.305	64.4	0.7906	0.6057	0.2150
P » 7 » .	377	107.1	18.4	11.29	3.065	63.9	0.9284	0.5428	0.1741
P » 13 » .	412	117.0	19.8	12.08	3.068	62.4	0.9448	0.5796	0.1782
P » 27 » .	349	99.1	20.2	12.48	3.361	60.2	1.0825	0.5784	0.1719
P » 56 » .	348	98.8	21.0	13.78	3.619	58.8	1.1484	0.7757	0.2008
NP » 7 » .	391	111.0	18.6	10.99	3.275	58.9	1.1302	0.6121	0.1614
NP » 13 » .	351	99.7	17.7	12.41	2.833	64.6	1.1390	0.6859	0.1744
NP » 27 » .	345	98.0	17.3	12.29	2.515	67.2	0.7605	0.5700	0.1506
NP » 56 » .	343	97.4	16.0	13.78	2.512	68.1	0.7307	0.4935	0.1471

Phosphorus, whether introduced singly or in combination with N, shows the same dependence, i. e. the more frequent the introductions of P and the lower its concentrations, the higher the coefficient of colloidality of the sugar beet grown ([9]).

A greater frequency in the introductions of nitrogen reduces the viscosity of the cellular sap (from 3.396 with 7 introductions of nitrogen to 2.305 with 56).

Phosphorus has the reverse effect, more frequent introduction increasing the viscosity of the sap; if introduced in combination with N, the dependence is the same as in the case of nitrogen alone, which would suggest that the latter plays the leading part.

The decreased viscosity of the sap, due to the fractional introduction of NP, causes the surface tension to increase.

The sugar content of the beetroot reaches its maximum value (20%) with 7 introductions of nitrogen, decreasing successively with more frequent introductions (at N with 56 introductions it is equal to 18.1%), but being in every instance above control (17.2%).

As to phosphorus, the more frequently it is introduced, the higher is the percentage of sugar (rising from 18.4 to 21%).

In the combination of N and P, the sugar content of the beet is affected by the antagonism between the two, the leading part being taken by nitrogen, which rejuvenates the whole body of the plant, so that the more frequent it was introduced, the lower was the sugar content of the beetroot.

The best crop (125%) was obtained with 7 introductions of nitrogen and with 13 introductions of phosphorus (117%), while the joint introduction of N and P gave the highest yield (111.07%) when repeated 7 times.

The total nitrogen content of the root is at its maximum when the nitrogen is introduced in 7 instalments, whereafter a rise begins and persists up to 27 introductions, when it is as high as 0.9287%; this shows that the nitrogen was being consumed by the plant right into the latest stages of its development.

Every fresh introduction of any element (N or P) stimulated the consumption of nitrogen, the introduction of phosphorus alone contributing to an even greater extent to the absorption of nitrogen. The joint introduction of N and P results in a better-balanced consumption of N, the maximum value being reached with 13 introductions of NP ([6],[10]).

The consumption of phosphorus is more energetic with a higher dosage, at N with 7 introductions it is 0.5281; at P with 7 introductions it is 0.5428, and, finally, at NP with 7 introductions it is 0.6159%, these figures being practically of the same order as the control data (0.5757); a further lowering of dosage (in each introduction), and an increased number of introductions give, in the case of nitrogen, a somewhat lower consumption of phosphorus by the plant, while, in the case of phosphorus, the consumption of P by the beet shows a steady increase.

The introduction of nitrogen in the later periods of development, while retarding the decomposition of proteins in the leaves, contributed to the reduction of the amount of soluble (harmful) nitrogen in the root.

A similar tendency was also displayed by phosphorus (Table).

1. The coefficient of colloidality of the sugar beet depends on the frequency of introduction and on the dosage of nutrient substances; besides, the more frequent are the introductions of nitrogen, and the lower its concentrations, the higher is the colloidality of the beet.

The influence of phosphorus is similar to that of nitrogen.

2. The viscosity of the sap decreases with an increase in the frequency of nitrogen introductions, and increases in the case of phosphorus.

With a decreased viscosity of the sap, the surface tension increases.

3. More frequent introductions of nitrogen cause its total amount in the root to increase (approaching control), whereas the phosphorus content decreases.

Frequent introductions of phosphorus result in an increased consumption both of phosphorus and of nitrogen by the plant.

4. The introduction of either nitrogen or phosphorus in the later periods of vegetation decreases the amount of the soluble (harmful) nitrogen in the roots of the beet.

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THE COLLOIDAL CHEMICAL COMPOSITION OF THE SUGAR BEET AS DETERMINED BY THE TIME OF INTRODUCTION OF NUTRIENT SUBSTANCES

The plastic and energizing substances forming part of a vegetative system along with the enzymes and the electrolytes determine both the architectonics of the cells and their biochemical properties connected with the progress of the metabolic processes. The electrolytes which lend a great mobility and diversity to the physico-chemical processes that occur in the vegetative cells, with every fresh combination of the latter, exercise an influence, that is peculiarly their own, on the whole of the vegetative system and, in the first place, on the colloid complex of the plasm, on the degree of its hydrophility.

The presence of electrolytes in the outer solution, their concentration affect most vitally the rate of their consumption by the plant, the formation

of the new organic substance and its properties. The frequence of the introduction of the principal nutrient substances—the electrolytes: nitrogen, phosphorus and potassium, determine both the size of the crop obtained and the physico-chemical composition of the plant itself ([1]—[10]).

As shown by a number of investigations, plants in their young age are very sensitive to the concentration of the outer medium, being able to absorb the necessary substances from weaker solutions ([11]—[13]).

Agricultural practice ([14]) would command a later introduction of part of N, P and K as affecting the plant in a way favouring an abundant beet crop.

The study of the colloidal chemical changes occurring within a plant if nutrient substances are introduced into it during the vegetation period provides a theoretical justification for agricultural practices and makes it possible so to control the growth of the sugar beet as to ensure a greater accumulation of substances favouring an abundant beet crop and to avoid an excess of substances harmful to the sugar-beet industry ([7], [10], [15], [16]).

This paper is the outcome of a study of colloidal chemical changes taking place in the sugar beet according to the time of introduction of N, P and K during the period of vegetation. The experiment was made on sand-grown plants (in 1936) on Belousov's nutrient mixture, both in its original composition and in our modification ([11]). In the latter case, when phosphorus and potassium were to be examined singly, they were introduced as $Ca(H_2PO_4)_2$ and KCl respectively. The sowing was made on June 3, the harvesting on October 20. The dates of introduction of nutrient substances were as follows:

1st date in filling the pots (sowing);
2nd » 7—8 pairs fully developed leaves;
3rd » 9—10 pairs of leaves;
4th » 12—13 » » »

The results are shown in the Table. The beet reacts on the introduction of N, P or K during the vegetation period by a change in its physico-chemical properties and its crop.

Nitrogen affects the crop the most if introduced in the earlier stages of development (2nd date).

Phosphorus gives the best crop if introduced at a somewhat later date (the 3rd).

Potassium is more effective if introduced at later date.

The simultaneous introduction of all the three elements (N, P, K) during the period of vegetation is most effective if performed at the third date, in the presence of 20 leaves. Ammonium sulphate gives a favourable effect if introduced (during the vegetation period) jointly with $CaCO_3$.

The coefficient of colloidality of the sugar beet ([7]) is affected by the time of introduction of nutrient substances into the plant in the following manner:

1) The dynamics of colloidality proceeds in a rising curve from lower frequency to higher ones, from 11.87 with 2 introductions of nitrogen to 16.75 with 4 introductions, i. e. the more frequently is nitrogen introduced, the higher is the coefficient of colloidality, which on the fourth introduction approaches control.

2) The influence of phosphorus is similar to that of nitrogen, i. e. colloidality is the higher the more frequently it is introduced.

3) Potassium results in a lowering of colloidallity if introduced at more frequent intervals.

4) The introduction of all the three elements (N, P, K) during the vegetation period gives a coefficient of colloidality that is the higher the more frequently they are introduced, in no case, however, does colloidality rise above control (where N, P and K are introduced on sowing).

Scheme	Weight of root		Sugar content %	Coefficient of colloidality (*K*)	Viscosity of sap	Surface tension	Content in root, in percentage of			
	g	%					Total N	P_2O_5	K_2O	Soluble N
Control: Belousov original	278	100.00	17.0	16.04	2.627	62.7	0.9394	0.8611	1.6990	0.1522
N during 2 periods	318	114.38	18.6	11.87	3.189	65.5	0.7184	0.5818	1.8283	0.1719
N » 3 »	315	113.30	17.0	14.23	2.898	67.9	0.7468	0.5494	1.4160	0.1536
N » 4 »	306	110.07	16.8	16.75	2.631	76.2	0.7781	0.5145	1.3620	0.0894
PK » 2 »	304	109.35	16.2	10.75	3.518	69.2	0.5022	0.6682	1.6428	0.1523
PK » 3 »	342	123.02	17.0	11.55	3.333	70.1	0.7897	0.6560	1.0548	0.1391
PK » 4 »	367	132.01	19.6	14.28	3.081	72.1	0.8978	0.6107	1.0206	0.1149
NPK » 2 »	342	123.02	19.6	14.22	3.201	65.4	1.0990	0.6006	1.7387	0.1436
NPK » 3 »	370	133.09	18.8	14.79	2.694	70.8	1.0768	0.6093	1.3927	0.1290
NPK » 4 »	323	116.18	16.5	15.80	2.651	76.7	0.8540	0.6156	1.3780	0.1723
$(NH_4)_2SO_4$ during 1 period . . .	269	96.76	17.6	15.61	3.210	61.3	0.6424	0.5269	1.6678	0.1627
$(NH_4)_2SO_4$ during 2 periods . . .	295	106.11	19.4	17.43	2.679	62.3	0.4284	0.7027	1.1731	0.0841
$NH_4)_2SO_4$ during 3 periods . . .	211	75.89	18.0	13.58	3.671	61.9	0.9073	0.6220	1.5029	0.1765
$(NH_4)_2SO_4$ during 4 periods . . .	174	62.58	16.0	13.05	3.261	58.7	1.0312	0.7307	1.2386	0.1120

Sand-grown crops 1936

Control Modification	352	100.00	17.2	13.69	2.154	69.1	0.8838	0.5757	0.7184	0.2440
P during 2 periods	364	103.40	18.7	11.89	2.443	70.6	1.1555	0.7423	1.1796	0.1739
P » 3 »	397	112.78	20.3	12.63	2.488	69.5	1.1513	0.5839	1.0515	0.1754
P » 4 »	382	108.52	20.9	14.07	2.540	67.3	1.0741	0.5628	1.0138	0.2128
K » 2 »	385	109.37	16.9	16.07	2.518	67.0	1.1761	0.5982	1.2966	0.1913
K » 3 »	435	123.57	18.0	16.05	2.421	68.0	1.1046	0.5666	1.2651	0.1938
K » 4 »	445	126.42	19.2	14.12	2.094	69.0	1.0455	0.5479	1.1923	0.2123
NP » 2 »	323	91.76	18.0	10.20	2.872	64.3	0.7362	0.5242	1.0792	0.1238
NP » 3 »	375	106.53	18.0	12.56	2.531	65.6	0.7816	0.5620	1.0246	0.1524
NP » 4 »	351	99.71	18.0	15.72	2.350	73.7	0.7641	0.6339	0.8810	0.1793
NK » 2 »	436	123.86	18.4	12.79	2.504	65.9	0.9125	0.6327	1.0283	0.1757
NK » 3 »	419	119.03	18.6	12.88	2.491	67.5	0.8761	0.5722	1.0134	0.1747
NK » 4 »	400	113.63	19.1	12.68	2.205	70.1	0.7667	0.5473	0.9671	0.1719

As regards joint introductions, only NK fails to affect colloidality to a marked extent; in all other combinations, the more frequent are the introductions, the higher is the coefficient of colloidality (*K*).

The introduction of NK is also important from another point of view: the accumulation of soluble (harmful) nitrogen in the root of the plant is due to the decay of part of the proteins and to the fact that products of decay find their way into the root ([10]); the introduction of a small dose of nitrogen in the latter half of the vegetation period retards the decay of the proteins in the leaf and diminishes the accumulation of soluble nitrogen in the root (Table); but, at the same time, the amount of hydrophile colloids contained in the latter is increased. As to potassium which reduces the colloidality of the root it contributes very materially to the accumulation of sugar. Consequently, an alternate introduction of N and K may retard the accumulation of soluble nitrogen, increase the sugar content and diminish the formation of hydrophile colloids in the root.

In vegetable matter the viscosity of the colloidal system which is an index of its degree of disperseness and hydration, depends on the conditions of

nutrition. The introduction at several times of N, P, K affects the viscosity of the cellular sap in the following manner:

In the case of nitrogen, the more frequent its introductions, the lower the viscosity of the sap.

In the case of phosphorus, the viscosity is slightly increased if the introductions are more frequent.

In the case of potassium, the more frequently it is introduced, the lower the viscosity of the sap.

Double and triple combinations give a one-peaked viscosity curve with a maximum at the second date of introduction, while for ammonium sulphate the maximum is at the third date.

With fractional introductions (N, P and K) the surface tension of the cellular sap shows an inverse dependence to that of viscosity.

As to the sugar content of the beet, nitrogen shows a maximum at the second introduction, nearing control at all the others; phosphorus produces the higher a percentage of sugar, the more frequently it is introduced; potassium yields the higher a sugar content the later (and the more frequently) it is introduced (fourth date); NPK yields the highest sugar content at the second date, with a gradual diminution at the subsequent ones.

The total nitrogen content [both as N and $(NH_4)_2SO_4$] is at minimum at the second date, with a gradual increase at subsequent introductions, as to the introduction of P, K and NPK, the maximum value is reached at the second date, diminishing at the subsequent ones. A change in the ratio of any of the principal elements (N, P, K) in the outer solution affects markedly the consumption of phosphorus by the plant, the maximum consumption of phosphorus taking place at an earlier, the second, date.

A similar effect is produced by potassium. The lack of any one element (N, P or K) in the nutrient solution causes a slowing down in the rate of absorption of potassium by the plant (the root), its minimum consumption taking place at the fourth date, and its maximum one at the second.

1. The coefficient of colloidality of the sugar beet and the physico-chemical constants of its sap (viscosity and surface tension) depend on the time of introduction of nutrient substances.

2. By combining the introductions of N, P and K with the various phases of development of the plant, high-grade beet may be obtained, i. e. one containing a minimum of hydrophile colloids and dissolved nitrogen.

3. The introduction of part of the nutrient substances (N, P, K) during the period of vegetation results in a more effective assimilation of the nutritive substances of the soil and an abundant beet crop.

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PLANT ANATOMY

ON THE NUMBER OF FIBRO-VASCULAR BUNDLES IN THE COLEOPTILE OF BARLEYS AND OATS

By M. S. JAKOVLEV

(Communicated by N. I. Vavilov, Member of the Academy, 28. VII. 1937)

The number of fibro-vascular bundles in the coleoptile of the wheat plant is, as shown by our investigations ([5]), a most characteristic feature for certain wheat groups.

The increase in the number of fibro-vascular bundles in the coleoptile was first observed by Percival ([8], [9]) in Indo-Abyssinian emmers, and then by Avery ([6]) in maize. The deviations found by the latter were so trifling, that the author did not ascribe to them any taxonomic significance, but used the data obtained for establishing the homology of the coleoptile of cereals. In addition to the coleoptile of maize Avery also studied that of oats and barley. That author, however, cites no data on the number of fibro-vascular bundles.

The deviation in the number of fibro-vascular bundles in the coleoptile can be utilized not only from the standpoint of the homology of the principal parts of the embryo of cereals, but also as a typical feature for characterizing the initial material as a wholly distinct geographico-ecological group. This character has not yet at all been considered from the standpoint of genetics. It could, nevertheless, be applied both in phylogenetic constructions and in the genetic analysis, as, for instance, in investigating congruent crossings. The significance of these latter for selection has been demonstrated by G. D. Karpechenko ([4]) with sufficient clarity. The value of such investigations is enhanced by the fact that the increase in the number of fibro-vascular bundles is directly associated with a more vigorous development of the young seedlings during their first stages of growth.

The present investigation included the samples of *Hordeum sativum* Jessen received by us from the world collections of the Union Institute of Plant Culture and representing 34 varieties and 6 wild species. In all 275 samples from various countries were studied and 5500 plants were examined.

The barley varieties of Abyssinia were studied in sufficient numbers. On the basis of the law of homologous series ([3]) the presence of many-bundled forms had been assumed by analogy with the wheats, the more so as Abyssinia is one of the main centres of origin of many varieties of *Hordeum sativum* Jessen ([1],[2]).

We therefore examined not only common widespread barley varieties, as for instance, var. *pallidum*, *nutans*, etc., but also many endemic forms, peculiar only to Abyssinia, as, for instance, var. *nigrinudum*, *Steudelli*, *abissinicum*, *macrolepis*, etc.

However, all the endemic barleys of Abyssinia were found to possess only two fibro-vascular bundles in the coleoptile. While the Abyssinian wheats, if classified according to this character, form a separate geographico-ecological group distinguished by a large number of fibro-vascular bundles, the Abyssinian barleys, on the contrary, behave differently. These have two fibro-vascular bundles, and we have not met any exceptions to this rule.

Contrary to the Abyssinian barleys, the group of endemic bald, beardless barleys (*Hordeum hexastichum* L.) from the Chinese centre of origin of cultivated plants can be said, if classified according to the number of fibro-vascular bundles, to form a distinct many-bundled group. To this group belong, for instance, var. *revelatum*, *nudipyramidatum* and *trifurcatum*, only an insignificant percentage of which have two-bundled coleoptiles. Here we mainly have coleoptiles with 3—5 bundles.

Deviations in the Number of Fibro-vascular Bundles in Barley Coleoptiles

Variety	Locality	Number of specimens	Number of plants examined	Number of fibro-vascular bundles			
				2	3	4	5
Pallidum Sir.	USSR	13	285	266	17	2	—
	Mediterranean area	15	300	294	6	—	—
Coeleste L.	Japan	3	60	55	5	—	—
	China	6	128	94	10	24	—
	Pamir	9	180	117	38	25	—
	Mongolia	44	884	469	189	226	—
	Afhanistan	12	271	93	51	126	1
	Abyssinia	7	140	140	—	—	—
Revelatum	Mongolia	1	25	—	—	25	—
Nudipyramidatum	Japan	2	40	38	2	—	—
	Mongolia	1	20	—	—	20	—
Sublatiglumatum Vav.	Afhanistan	1	25	24	1	—	—
Trifurcatum Schlecht	Mongolia	4	80	18	25	34	3
	India	1	20	10	7	3	—

The *coeleste* veriety is most interesting. It occurs both in Abyssinia and in Asia; all the forms, originating from Eastern Asia (i. e. from the centre of concentration of manifold bald furcated and short-bearded forms) also show the greatest variety in the number of vascular bundles. Some forms as, for instance, v. *coeleste* f. *Karzinianum* from China, gave many-bundled (4—5) coleoptiles only. On the contrary, all the Abyssinian forms of v. *coeleste* were two-bundled.

The two-bundled coleoptile forms can also be said to comprise v. *pallidum* and also the group of cultivated two-rowed barleys (*H. distichum* v. v. *medicum*, *nigricans*, *nutans*, etc.). Coleoptiles with a greater number of fibro-vascular bundles are of very rare occurrence in this group.

We shall now pass on to an examination of the number of fibro-vascular bundles in the coleoptile of those cereals, which do not form a wholly homogeneous group as regards origin. Such are the oats, the origin of which cannot be ascribed to any one geographical centre. «Cultivated oats are of an undoubtedly polyphyletic origin. Various species were probably introduced into cultivation independently» [page 60, (1)]. N. I. Vavilov indicates five centres of the formation of cultivated oats varieties.

In accordance with the centres of origin of cultivated oats the following were examined. *Av. sativa* L., *byzantina* Koch, *abyssinica* Koch., *strigosa* Schreb., *brevis* Rath., *brevis* Vav., *orientalis* Schreb., *nuda* L., and the wild oats: *Av. Ludoviciana* Dur., *fatua* L., *sterilis* L.

In all 65 samples were studied and 1300 young seedlings were examined.

As regards the number of fibro-vascular bundles in the coleoptile the oats were found to be very homogeneous, contrary to what we see in wheat and barley. The oats did not display and increase in the number of fibro-vascular bundles. If in some cultivated plants this character distinguishes definite geographical groups (wheats, barley), the same cannot be said of oats.

Oats are the youngest polyphyletic of cultivated plants and belong to the so-called «secondary cultures». Endemism is less apparent here than in the principal oldest «primary cultures»*. The presence of a large number of fibro-vascular bundles is typical of the group of primary cultures and is essentially an endemic character. Among the cultivated oats there need not necessarily be those deviations from the usual number of fibro-vascular bundles, that we have in wheats and barley.

From the standpoint of structural metamorphosis, the coleoptile is a leaf-formation, as has been proved by a number of papers on the homology of the embryos of cereals. We may mention the latest investigations of McCall (7), in which the author, on the basis of an extensive study of literature and of his own experiments with seedlings of two varieties of soft wheats, considers the coleoptile as a third leaf originating in the region of third node of the young seedling.

The examination of a large number of samples of *Hordeum sativum* Jessen, and of various species of *Avena* L. permits of the following main statements to be made:

The species and varieties of cultivated cereals, having a large number (2—5) of fibro-vascular bundles in their coleoptile, have preserved structural features peculiar to the oldest forms. During the process of evolution, there occurred a reduction of the fibro-vascular system of the coleoptile, which is a leaf formation.

An increase in the number of fibro-vascular bundles in the coleoptile is peculiar of certain endemic forms and is typical of primary cultures.

A larger number (2—5) of fibro-vascular bundles was found in bald forms of barley. All the other forms of barley have essentially two fibro-vascular bundles, such deviations as occur in some forms being insignificant.

No deviations from the usual number of fibro-vascular bundles were recorded among either the cultivated or the wild oats. The coleoptile of the various species of oats is characterized by two bundles only.

During germination, the plants having a larger number of bundles in the coleoptile, develop the most vigorously. It appears that the genetic and physiological nature of many-bundled plants is different. Hence the necessity of a more extensive study of all the peculiarities and properties of these plants for the purpose of creating new highly productive varieties.

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* The conception of primary and secondary cultures is taken from N. I. Vavilov's paper «Ботанико-географические основы селекции» (1935).

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PHYTOPATHOLOGY

ON THE HARMFULNESS OF ANTHRACNOSE OF BLACK CURRANT

By K. T. SUKHORUKOV and O. B. NATALJINA

(Communicated by A. A. Richter, Member of the Academy, 13. VII. 1937)

The anthracnose of currant, caused by the fungus *Pseudopeziza ribis* Kleb., is the main disease of all varieties of the currant—black, red and white.

Anthracnose is a widespread disease in all those localities where currants are cultivated on an industrial scale (the central belt of the RSFSR, Leningrad territory, White Russian SSR, the Far Eastern territory) and is rarely encountered in the South (Azovo-Chernomorsky territory and the South-East of the USSR). The dynamics of the development of anthracnose is distinguished by its relatively late appearance (in June) and by the mildness of its symptoms in cases of initial infections. Anthracnose attains considerable development in the latter half of summer (the end of July, and August), spreading during the entire season by means of repeated infections with the summer conidial spores (*Gloeosporium ribis* Mont. et Desm.).

In plants suffering from anthracnose there occurs a wilting or considerable fall of leaves, depending on the severity of the infection by the fungus.

In view of the late development of this disease and also of the fact that injury to the leaves occurs just before the autumnal leaf-fall, this disease was considered by practical botanists as harmless. The harmfulness of anthracnose for the currant plant under the conditions existing in the USSR was first indicated by Natal'jina (3), who demonstrated the effect of spraying during the summer on the development of the disease and on the yield of berries.

In his fundamental review of anthracnose Blodgett (1) does not discuss the question of its harmfulness. March and Maynard (2) indicate a 26% increase in the yield of currant shrubs protected from anthracnose, a 14.3% increase in the size of the buds and 15.3% in their weight.

The object of our investigation was to determine the effect of different degrees of severity of the infection on the dynamics of the accumulation and expenditure of the main reserve substances in stems during the autumn-winter period of 1935—36, and, in connection with this, to compare the development of the plants in the next vegetative season, 1936.

Method. In field plantations of four-year-old black currants (of the Lia Plodorodnaia variety) plots were isolated on which various degrees of infection with anthracnose were obtained by means of a system of protective sprayings.

Table 1 shows the state of the leaf surface on the experimental plots on September 15, 1935, as correlated with the number of sprayings.

Table 1

No	Variant	Percentage of leaf surface infected
1	Control (not infected, 6 sprayings)	2.8
2	Mild infection (4 sprayings)	16.84
3	Medium infection (3 late sprayings)	42.80
4	Severe infection (no spraying)	71.61

On these plots were marked separate shrubs, from which two-year-old branches were cut off periodically (once a month) for analysis.

To stop fermentation the cut branches were fixed by desiccation at 80° C, then comminuted and analysed for total content of carbohydrates and lipoids. The lipoids were determined by extraction of dry matter by petroleum ether in Soxlet's apparatus. The carbohydrates (starch, dextrines and sugars) were determined in samples freed of fat by petroleum ether after treatment with diastase and hydrolysis by hydrochloric acid. Determination after Bertrand's method.

The results of the analyses for carbohydrates are summarized in Table 2.

Table 2

(In percentages to dry weight of sample)

No	Variant	13 August		13 September		20 October		20 December		20 April	
		%	Differ. from control	%	Differ. from control	%	Differ. from control	%	Differ. from control	%	Differ. from control
1	Control (not infected) . .	0.45	—	0.96	—	1.27	—	1.61	—	1.32	—
2	Mild infection	0.51	+11.5	1.07	+11.1	1.21	— 4.8	1.26	—21.8	1.19	— 9.9
3	Medium infection	0.44	— 2.3	0.91	— 5.3	1.06	— 8.7	0.98	—38.6	0.92	—30.4
4	Severe infection	Traces	—	0.92	— 5.2	0.97	—23.7	1.01	—37.1	0.87	—32.6

As shown by the above-tabulated data, there is no marked difference in the first analyses between the different degrees of infection as regards content of carbohydrates. Mild infection at first stimulated the accumulation of reserve carbohydrates in the wood.

Medium and severe infections subsequently showed a considerable fall in carbohydrate content, the latter attaining 32.6 to 37.1%.

The latest analyses (20 IV) showed a drop of 9.9% in carbohydrate content for mild infection.

Table 3 gives the content of lipoids as a percentage of the dry weight of the sample.

With a mild infection there was no marked difference in the content of lipoids. The last analyses of medium and severe infections showed a drop of 28.5 and even 33.4%.

We then studied the growth and fructification of the experimental plots in the vegetative season of 1936. The uninfected plots used as control differed markedly from the rest by the earlier development of their leaves (27 IV), the earlier commencement of growth. The plants suffering from medium and severe infection showed a retarded development of their leaves.

Table 3

Variant	13 August		13 September		20 October		20 December		20 April	
	%	Differ. from control	%	Differ. from control	%	Differ. from control	%	Differ. from control	%	Differ. from control
1. Control (not infected) . . .	1.19	—	1.55	—	1.67	—	1.93	—	1.83	—
2. Mild infection .	1.20	+ 1.0	1.50	— 3.4	1.90	+13.7	1.87	— 7.9	1.79	— 1.2
3. Medium infection	1.21	+ 1.6	1.52	— 2.0	1.70	+ 1.7	1.69	—12.5	1.31	—28.5
4. Severe infection	0.95	— 9.7	1.02	—34.2	1.22	+27.0	1.56	—20.2	1.22	—33.4

The size of the buds at the time of their opening differed noticeably in healthy and in infected plants, as is evident from the figures contained in Table 4.

Table 4

No	Variant	Length of bud in cm	Percentage to control	Difference from control
1	Control (not infected)	1.29	100	—
2	Mild infection	1.06	82.1	—17.9
3	Medium infection	0.97	75.1	—24.9
4	Severe infection	0.86	66.1	—33.4

The yield of the experimental plots showed a small drop (—7.2%) with a mild infection, and a marked drop with medium and severe infections, i. e. 35.5 and 52.8% of control.

Table 5

Yield of the Experimental Plots and the Degree of Infection
(Mean of three tests)

No	Variant	Average weight per plot in kg	In percentage of control	Difference from control
1	Control (not infected)	16.88	100	—
2	Mild infection	15.85	92.8	— 7.2
3	Medium infection	10.96	64.5	—35.5
4	Severe infection	8.07	47.2	—52.8

The increase in height of the shrubs on the experimental plots differed during the whole season. Table 6 demonstrates this according to the measurements recorded for September 15, 1936.

A 18.4 or 35.2% decrease in the rate of growing was essential for the currant shrubs—the affected shrubs differed markedly from control in height and width.

The result of these investigations justify the following conclusions:

1. The degree of infection with anthracnose is associated with a marked

Table 6

(Mean for 100 shoots)

No	Variant	Increase in height in cm	Percentage of control	Difference from control
1	Control (not infected)	75.04	100	100
2	Mild infection	68.17	90.9	— 9.1
3	Medium infection	61.17	81.9	—18.4
4	Severe infection	48.59	64.8	—35.2

fall in the reserve of the main plastic substances (carbohydrates and lipoids) in the perennial parts of the currant shrub in the autumn-winter period.

2. The drop of 30.0—32.6% in carbohydrate reserve and of 28.5—33.4% in lipoid reserve observable under the action of anthracnose in the autumn-winter period affected the main indices of growth of the plant and lowered the yield by 35.5—52.8%.

3. The harmfulness of anthracnose depends on the degree of infection.

4. The demonstrated harmfulness of anthracnose indicates the economic significance of this disease, thus proving the necessity of controlling it and of studying the resistance of plants to it.

In view of the decrease of nutrient reserves in the branches of the currant shrub, it is necessary to determine the influence of anthracnose on the frost-resistance of the currant, as the phenomenon of «chilling» is frequently observed in this culture. There is reason to suppose that anthracnose lowers the winter-hardiness of this plant.

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ZOOLOGIE

AERODYNAMISCHE EIGENTÜMLICHKEITEN DER INSEKTEN

Von I. ŠVAIKOVSKIJ

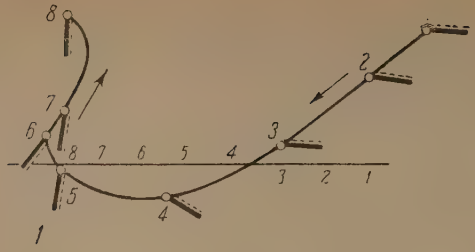
(Vorgelegt von S. A. Zernov, Mitglied der Akademie, d 19. VIII. 1937)

Bei den modernen Flugzeugen mit Schraubenpropeller erreicht C_y/C_x (das Verhältnis des Auftriebs zum schädlichen Widerstand) nur selten den Wert 15—16, während es bei den Insekten und Vögeln einige Male grösser ist und zuweilen 95 beträgt. Bull stellte als erster die Frage über die Propellerwirkung des schwingenden Flügels.

Bei den meisten Insekten hat der Körper eine Haardecke, während die Flügeloberflächen entweder behaart, geschuppt oder geriffelt sind. Zwischen den Körper- und Flügelhaaren, zwischen den Fältchen der Riffelung und zwischen den Flügelschuppen befinden sich Luftschichten. Während des Fluges sind die inneren Teile dieser Luftschicht fast unbeweglich, und deren Beweglichkeit nimmt in Richtung nach den äusseren Schichten hin zu. Beim Fluge findet eine starke Reibung zwischen den äusseren Teilchen und dem umgebenden Luftmedium statt, dessen an der Oberfläche in der Nähe der Decken befindlichen Luftteilchen in rotierende Bewegung geraten; dieser Mechanismus wirkt wie eine ideale «Luftkugellagerschicht». Aus diesem Grunde wird die Umströmung des Körpers und der Flügel ausserordentlich verbessert. Die Behaarung, Schuppung und Riffelung der Flügeloberflächen vergrössern deren Fläche; hierzu im Ausgleich sind die Flügel oft verkürzt und schmal geformt. Dieser letztere Umstand macht den Flügel beweglicher und sparsamer im Energieverbrauch; denn dessen Hebelarm ist somit sowohl der Länge als auch dem Querschnitt nach kleiner.

Aus der schematischen Darstellung des Querschnitts der Brust einer Fliege (Magnan) ist zu sehen, dass der Flügel aktiv durch die Muskulatur gehoben wird. Die aktive, durch Muskeln bewirkte Erhebung des Flügels erklärt die Eigentümlichkeiten der Propellerwirkung der oberen Oberfläche des Flügels beim Aufsteigen.

Bull sprach den Gedanken aus, dass beim Senken der Flügel das Insekt sich in der Luft halte, während es beim Heben derselben sich vorwärts bewege; dieser richtige, durch die Erfahrung nicht gestützte Gedanke, blieb unbeachtet. Die Augenscheinlichkeit desselben wird durch eine Reihe von mir durchgeführter Versuche bewiesen. In der Abb. 1 ist eine Sinusoide abgebildet, die von dem Flügelende einer Fliege (*Volucella*) beim freien Fluge beschrieben wird. In den Stellungen 1—8 sind die Flügelquerschnitte abgebildet; die ununterbrochene Linie bedeutet die untere, und die punktierte—die obere Oberfläche. In der Abb. 2 sind in der 2. Stellung die Flügel gesenkt. Y ist der Auftrieb, der auf die untere Oberfläche wirkt. In der Abb. 3 ist die 4. Stellung bei gesenkten Flügeln gegeben. Der Luftwiderstand Y_1 setzt sich aus den Kräften l und K zusammen, wo $l > K$; l ist der Auftrieb. Die Abb. 4 zeigt die 6. Stellung beim Heben des Flügels, Z ist der Luftwiderstand, der



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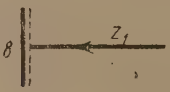

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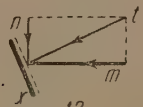

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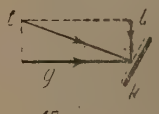

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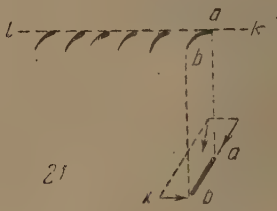

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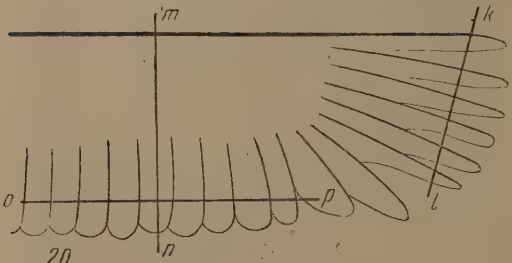

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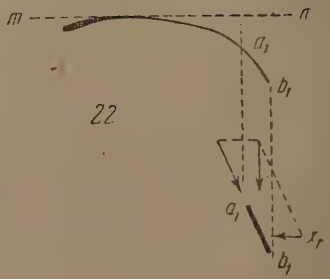
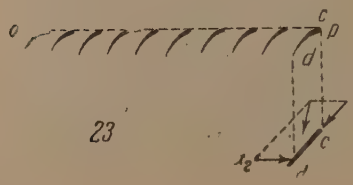


22



23

auf die obere Oberfläche von hinten gerichtet ist. Aus dem Parallelogramm der Zerlegung der Kraft Z erhalten wir die Kräfte m und n, wobei $m > n$. m ist die Propellerkraft, die auf die obere Oberfläche wirkt. In der Abb. 5 in der 8. Stellung bedeutet Z_1 die gesamte Propellerkraft, die auf die obere Oberfläche wirkt. Folglich dient die untere Flügeloberfläche beim Senken hauptsächlich als Elevator, während die obere Oberfläche beim Heben in der Hauptsache als Propeller wirkt.

Das Flügelende von *Volucella* beschreibt in bezug auf den Körper eine geneigte Acht, die bei dem auf einer Nadel aufgesteckten Insekt gut zu sehen ist. In freien Fluge beschreibt das Flügelende eine Sinusoide (Abb. 1). Die Stellungen der Sinusoide *1—5* (Abb. 1) stellen die Neigung dar, die wir bei der geneigten Acht beobachten, die von dem Flügelende des aufgesteckten Insekts beschrieben wird. Wenn beim Senken die untere Flügeloberfläche als Propeller dienen würde, so würde dieser Teil der Sinusoide etwas schräger geneigt und die Stellung *5* mehr nach vorn verschoben sein. Aber das ist nicht der Fall; also dient beim Senken die untere Oberfläche als Elevator. Beim Heben, wenn das Insekt befestigt ist, geht das Flügelende rückwärts, jedoch auf der Sinusoide, d. h. im Fluge, zeigen die Stellungen *6*, *7* und *8* (Abb. 1), dass das Flügelende nicht zurück sondern auch oben gegangen ist. Dies konnte nur bei einer Vorwärtsbewegung des Insekts erfolgen, die auch infolge der Propellerwirkung der oberen Flügeloberfläche beim Heben des Flügels stattfindet. Also wirkt in der Hauptsache die untere Flügeloberfläche beim Senken als Elevator und die obere beim Heben—als Propeller.

Es ist festgestellt, dass der Flügel des Insekts sich 1.5 mal so schnell aufhebt wie senkt; bei der Hausfliege ist dieses Verhältnis 1.7; bei der Hummel—1.8; bei der Zimmermannshummel—1.3. Wenn man die grössere Geschwindigkeit und Aktivität des durch Muskelkraft bedingten Hebens des Flügels in Betracht zieht, so wird klar, dass beide Umstände die Propellerwirkung der oberen Flügeloberfläche beim Steigen verstärken.

Die Abb. 6—9 geben die Achten in verschiedenen Neigungen wieder. Aus den Abb. 10 u. 12 ist ersichtlich, dass diese Acht mehr schräg liegt, eine grössere Propellerwirkung besitzt als die Acht in den Abb. 11 und 13, die mehr steil ist. Aus den Abb. 12 und 13 ist ersichtlich, dass die Propellerkraft $m > m_1$. In den Abb. 14 und 16 ist keine Propellerkraft vorhanden. Hier haben wir stehenden Flug. Die Abb. 15 mit der Acht in umgekehrter Richtung stellt den Flug nach rückwärts mit dem Bauch nach vorn dar. Die Abb. 17 gibt die Propellerkraft G wieder, die von vorn nach hinten gerichtet ist (Goldkäfer). Auf Grund meiner Versuche kann man behaupten, dass im wesentlichen die obere Oberfläche beim Heben des Flügels als Propeller und die untere Oberfläche beim Senken als Elevator wirkt.

Die Steuerung und Manövrierung wird durch verschiedene Neigungen der Acht jedes Flügels bewerkstelligt (bei den Fliegen und *Hymenoptera)* oder sogar durch Ausschalten eines derselben; so fliegt die Biene nach der Seite des ausgeschalteten Flügels hin (tragende Oberfläche), wo die Acht des anderen Flügels (Abb. 18 und 19) als Propeller dient; hier ähnelt das Insekt dem «Luftfisch». Die Amplitudenunterschiede de sFlügelschwungs bewirken die Steuerung. Die Verschiebung des Schwerpunktes infolge von Beugungen des Leibes und Veränderungen der Bein- und Kopfstellung stellen die Steuerung dar.

Zur Aufklärung der Vorgänge beim natürlichen Fluge muss der Zustand der Luft um die schwingenden Flügel herum untersucht werden. Magnan stellte mit aufgesteckten Insekten Rauchversuche an. Da die Objekte klein waren, so war auch das aerodynamische Spektrum klein, verschwommen und unklar. Ich konstruierte ein Gerät mit einem Bandspektrum und Insektenmodelle mit einer Flügelweite von 65—70 cm. Die Flügel wurden durch

Gummischnüren in Bewegung gebracht. Bei dem Modell, dessen Vorder- und Hinterränder fest waren (was in der Natur nicht der Fall ist), findet beim Flügelschlag an beiden Rändern wegen der Luftverdünnung in deren Schwingungszone ein Ansaugen der Bänder statt. Beim Modell mit elastischem (wie in der Natur) Hinterrand werden die dahinter liegenden Luftschichten beim Flügelschlag abgestossen; aus diesem Grunde wird das Ansaugen der Bänder an dem Vorderrand bedeutend verstärkt, was gleichfalls an dem Vorderrand in dem vorhergehenden Versuche nur mit geringerer Kraft wegen des festen Hinterrandes zu beobachten war. Also erfolgt bei Versuchen mit befestigten Objekten am Vorderrand des natürlichen Flügels ein Ansaugen und am elastischen hinteren Flügel—ein Absaugen der Luft vor; hier findet der Luftzug von vorn nach hinten infolge der Verdünnung der Luft und der Elastitizität des Hinterrandes statt. In der Natur hingegen, beim freien unbefestigten Fluge wird umgekehrt vor dem Vorderrand der Flügel ein dieselben nach vorn ziehendes, wie ein Propeller wirkendes Luftmedium erzeugt; die hintere Luftschichten stossen das Insekt vorwärts, d. h. wirken wie ein Propeller.

Durch Herausnehmen einzelner Teile des Bandspektrums, stellte ich fest, dass am Ende des Vorderrandes das Ansaugen grösser ist als an der Flügelbase, denn am Ende ist die Verdünnung grösser infolge der grösseren Geschwindigkeit der Bewegung des Flügelendes im Vergleich zu dem Teil neben der Base. Das stärkere Ansaugen am Ende des Vorderrandes ist ausserdem durch das Absaugen auf der entgegengesetzten Seite—am Ende des Hinterrandes—zu erklären. Beide Erscheinungen verstärken einander. Am Teil des Hinterrandes, der ungefähr von der Mitte bis zur Base des Flügels geht, beobachtete ich ein Ansaugen, das offenbar vom Geschwindigkeitsunterschied der Strömungen beim Flügelende und dessen Base, die von vorn nach hinten gehen, herrührt. Die schnellere Strömung am Ende des Hinterrandes lässt, indem sie die mittlere, langsamere Strömung überholt und nur die ihre nächstgelegene austösst, dieselbe längs einer Kurve gehen und zum Hinterrand an der Flügelbase als ansaugende Strömung zurückkehren.

Um meine künstlichen grossen Modelle zu prüfen, stellte ich einen Versuch mit einem Adlerflügel an und erhielt die gleichen Resultate.

Die sehr voneinander abstehenden Schwungfedern am Ende des Vogelflügels (Fig. 20) wirken beim Heben als Propeller (Abb. 21); hier bedeutet X die Propellerkraft. Die hinteren Schwungfedern (Abb. 22) biegen sich beim Heben nach unten und dienen als Propeller; X_1 ist die Propellerkraft. Aus der Abb. 3 ist ersichtlich, dass die Kraft X_2 beim Heben den Flügel in gespreizter Form zu halten und ihn sogar vorwärts zu tragen strebt. Auf diese Weise wird beim Flügelheben bei den Insekten (und Vögeln) im wesentlichen die Propellerkraft erzeugt; beim Senken jedoch dienen die Flügel hauptsächlich als Elevatoren. Ausserdem bildet sich vor dem Vorderrand in der Schwingungszone eine Propellerzugkraft, die eine Folge der huffverdünnung in der Schwingungszone der Flügel und der Elastizität des Hinterrandes beim natürlichen Flügel ist.

Ausser der Arbeit in Laboratorium machte ich persönlich auf Flügeln von Insektentyp mit einer Spannweite von 5 m einige Flüge auf einem Hebel mit Gegengewicht und erhob mich, indem ich mein Gewicht bis auf 4—10 kg brachte, bis zu 5 m Höhe. Auf dem Flugplatz erhob ich mich mittels eines Kugelspringers (das ganze System ist schwerer als die Luft) ohne Anstoss von der Erde und flog biszu einer Höhe von 8—10 m. Mit den Flügeln erzeugte ich die achtförmigen Bewegungen der Insekten. Bei diesen Flügen wurde von mir zum ersten Male eine Methode zur Fluguntersuchung mit vermindertem Gewicht des Menschen benutzt.

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EXPERIMENTELLE ZOOLOGIE

DIE MORPHOGENETISCHE AKTIVITÄT DER VERSCHIEDENEN TEILE DER HYPOPHYSE

Von A. A. VOITKEVIČ (WOITKEWITSCH)

(Vorgelegt von I. I. Schmalhausen, Mitglied der Akademie, d. 10. VIII. 1937)

VII. DER WACHSSTIMULIERENDE EINFLUSS DER «EOSINOPHILEN ZONE» DES HYPOPHYSEVORDERLAPPENS UND ANDERER ENDOKRINEN ORGANE

Wie schon früher gezeigt wurde ([9], [10], [11]), wird bei Amphibienlarven durch Implantation von Gewebeelemente der «eosinophilen Zone» des Hypophysevorderlappens bedeutende Stimulierung des Wachstums hervorgerufen.

Jedoch aus den Angaben einer Reihe von Autoren ist bekannt, dass nicht nur die Hypophyse, sondern auch andere endokrinen Drüsen die Fähigkeit besitzen das Wachstum der Amphibien zu beschleunigen, z. B. die Rindschicht der Nebennierendrüse und Parathyreoidea*. Dieser Umstand veranlasste uns, ein Vergleich zwischen dem Einfluss des Hypophysevorderlappens auf das Wachstum und dem Einfluss der Nebennieren und Parathyreoidea auf dasselbe auszuführen, und durch Versuche festzustellen, ob es möglich ist bei kombinierter Einführung der Hypophyse und genannter Drüsen das Wachstum weiter zu stimulieren, d. h. ausser den Grenzen, welche wir mit Implantation von der «eosinophilen Zone» erreichen.

Die Wachstumsbeschleunigung der Kaulquappen, bei Implantation von Gewebestückchen der Rindschicht von Nebennieren wurde schon früher beobachtet ([9],[10],[11])**. Zwecks Gegenüberstellung dieser Resultate mit den Wirkungen der Hypophyse wurden neue Versuche unternommen, in denen die Implantation der Vorderlappensubstanz («eosinophile Zone») und Nebennieren in parallelen Serien und an gleichem Material ausgeführt wurden. In anderen Kaulquappengruppen wurde eine kombinierte Einwirkung beider Drüsen an denselben Tieren untersucht.

Die Auswahl des Materials und Methodik waren dieselben wie in den vorhergehenden Mitteilungen. Frische von dem Schlachthof bekommene Hypophyse (Rind) wurden in Stückchen zerschnitten (1.5 und 2 mg) (die Abwesenheit in den Transplantaten Gewebefragmente aus anderen Zonen wurde

* Es liegen Angaben vor, in welchen behauptet wird, dass auch die Thymusdrüse die genannte Eigenschaft besitzt. Jedoch in einer früher von uns veröffentlichten Arbeit wurde gezeigt, dass nur bei Fütterung mit der Thymusdrüse eine Wachstumstimulierung beobachtet wird, bei Implantation von Stückchen dieses Organs konnte ein solches Resultat nicht festgestellt werden.

** Siehe auch die Arbeiten von Gudernatsch ([1],[2]), Romeis ([6]), van-Herverden ([8]), Křiženecky ([3]).

histologisch nachgeprüft), welche zu gleicher Zeit 20 und mehr Kaulquappen implantiert wurden. Die Resultate der ersten Versuchsgruppen sind in Tabelle 1 angeführt.

Tabelle 1

Die Entwicklung der Kaulquappen bei Implantation der Nebennierenrindschicht und der «eosinophilen Zone» des Hypophysevorderlappens

Tage nach dem Versuchsbeginn	Serie	Gewicht in mg			Länge in mm		
		Gesamtgewicht der Kaulquappen	Schwanz	Hintere Extremität	Gesamtlänge der Kaulquappe	Schwanz	Darmkanal
5	Kontrolle . .	317.0	66.0	4.2	31.4	21.1	99.5
5	Nebennierenrindschicht .	330.0	73.0	4.5	31.0	21.3	95.7
5	Hypophysevorderlappen .	318.0	86.5	6.3	35.7	23.3	117.3
5	Nebennierenrindschicht+ +Vorderlappen	372.0	76.0	4.5	34.5	22.0	107.4
10	Kontrolle . .	340.0	73.0	9.5	34.1	22.9	111.4
10	Nebennierenrindschicht .	360.0	70.0	4.9	32.3	19.3	107.3
10	Hypophysevorderlappen . .	547.0	99.5	9.5	36.8	24.2	121.1
10	Nebennierenrindschicht+ +Vorderlappen	490.0	92.0	6.2	35.7	22.9	122.9

Die Analyse der erhaltenen Angaben zeigt, dass die Substanz der «eosinophilen Zone» des Vorderlappens, wie auch früher, das Wachstum beschleunigt, besonders scharf ist dies an 10. Versuchstage zu bemerken. Die Nebennierenrindschicht stimuliert das Wachstum ebenfalls etwas, jedoch bedeutend geringer als die Hypophyse. Im Falle einer kombinierten Einwirkung (Hypophyse und Nebennieren) bleibt die Wachstumsbeschleunigung unverändert: zum 5. Versuchstag ist das Gesamtgewicht der Kaulquappen dieser Serie etwas höher: zum 10. Tag kleiner, als in der Gruppe, welche nur «eosinophile Zone» implantiert bekam.

In einer Reihe analoger Versuche konnten wir die hier angeführten Resultate im allgemeinen bestätigen; wir könnten sie hier nicht alle anführen und werden nur noch die Angaben eines Experiments wiedergeben (Tabelle 2), wo die Versuchsdauer 15 Tage war und das Gewicht des Implantats 3 mg betrug.

Auch hier sehen wir, dass die Wachstumsbeschleunigung unter dem Einfluss der implantierten Nebenniere bedeutend geringer ist als wie bei kombinierter Einwirkung oder auch Hypophyse allein.

Gleichzeitig wurden auch Versuche mit der Parathyreoidea angestellt. Bezüglich ihrer Wirkung auf das Wachstum der Kaulquappen sind Angaben bei Romeis (7) angeführt, wo gezeigt wurde, dass bei Fütterung mit getrokkneter Parathyreoidea das Wachstum stimuliert wird. In letzter Zeit beobachteten Prowocheński u. Slizyński (4,5) in Versuchen an Vögeln die Neutralisierung des morphogenen Effekts (Mauser), welchen die Schilddrüse hervorruft, bei gleichzeitiger Einführung Schilddrüse+Parathyreoidea. Analoge Resultate erhielten sie auch an Kaulquappen: die Substanz der Parathyreo-

Tabelle 2

Die Entwicklung der Kaulquappen bei Implantation der Nebennierenrindschicht und der «eosinophilen Zone» des Hypophysevorderlappens

Serie	Gewicht in mg			Länge in mm		
	Gesamtgewicht der Kaulquappe	Schwanz	Hintere Extremität	Gesamtlänge der Kaulquappe	Schwanz	Darmkanal
Kontrolle	320.3	70.0	11.5	30.8	19.1	80.0
Nebennierenrindschicht . .	341.0	72.8	10.2	30.8	18.0	86.0
Hypophysevorderlappen . .	488.1	89.4	14.0	34.0	21.9	91.8
Nebennierenrindschicht + + Vorderlappen	465.0	78.3	15.6	34.2	22.1	90.2

idea hemmte die Metamorphose, d. h. eine Wirkung, welche auch die Substanz der «eosinophilen Zone» des Vorderlappens hervorruft ([9],[10], [11]). Die Versuche über die Parathyreoideadrüse wurden in derselben Weise angestellt, wie die oben beschriebenen. In Tabelle 3 sind die Versuchsresultate angeführt mit einer Einschätzung des Effekts am 5. und 10. Tage und in Tabelle 4 ein Versuch mit einer Dauer von 15 Tagen.

Tabelle 3

Die Entwicklung der Kaulquappen bei Implantation der Parathyreoideadrüse und der «eosinophilen Zone» des Hypophysevorderlappens

Tage nach dem Versuchsbeginn	Serie	Gewicht in mg			Länge in mm		
		Gesamtgewicht der Kaulquappe	Schwanz	Hintere Extremität	Gesamtgewicht der Kaulquappe	Schwanz	Darmkanal
5	Kontrolle . . .	317.0	66.0	4.2	31.4	21.1	99.5
5	Parathyreoidea	354.0	80.0	6.6	33.4	22.2	112.1
5	Hypophysevorderlappen . .	318.0	86.5	6.3	35.7	23.3	117.3
5	Parathyreoidea + Vorderlappen	517.0	96.5	8.3	36.1	23.9	131.6
10	Kontrolle . .	340.0	73.0	9.5	34.1	22.9	111.4
10	Parathyreoidea	349.0	82.0	9.0	35.0	22.0	86.0
10	Hypophysevorderlappen . .	547.0	99.5	9.5	36.8	24.2	121.1
10	Parathyreoidea + Vorderlappen	596.0	103.5	10.0	37.4	24.3	119.7

Die Resultate der Implantation von Parathyreoideastückchen sind analog denen, welche wir mit den Nebennieren erhielten: es findet eine, ganz leichte, Wachstumstimulierung statt, aber eine bedeutend geringere als der Effekt mit der Hypophyse. Etwas unerwartet sind die Resultate bei kombinierter Einwikung (Hypophyse+Parathyreoidea): das Wachstum der Larven wird bedeutend mehr beschleunigt als wie bei der Einführung der Hypophyse allein.

Das Gesamtgewicht der Kaulquappen nach 5 Tagen bei kombinierter Einwirkung ist im Durchschnitt 200 mg höher als bei der Kontrolle und den hypophysierten Kaulquappen. Nach 10 Tagen ist der Unterschied etwas ausgeglichen, jedoch bleibt das Übergewicht bei kombinierter Einwirkung auf Seiten der Kaulquappen bestehen.

Die erhaltene Angaben wurden mit dem nachfolgenden Versuch bestätigt, die Versuchsdauer war 15 Tage.

Tabelle 4

Die Entwicklung der Kaulquappen bei Implantation der Parathyreoideadrüse und der «eosinophilen Zone» des Hypophysevorderlappens

Serie	Gewicht in mg			Länge in mm		
	Gesamtgewicht der Kaulquappe	Schwanz	Hintere Extremität	Gesamtlänge der Kaulquappe	Schwanz	Hintere-Extremität
Kontrolle	320.3	70.0	11.5	30.8	19.1	80.0
Parathyreoidea	387.5	75.5	14.4	31.7	18.6	80.8
Hypophysevorderlappen . .	488.1	89.4	14.0	34.0	21.9	91.8
Parathyreoidea+Vorderlappen	566.7	123.3	26.5	39.0	26.7	76.7

Im gegebenen Fall, sowie auch in vorhergehendem Versuch, sehen wir bei der kombinierten Serie (Parathyreoidea+Hypophyse) maximale Wachstumstimulierung. Die Länge der Kaulquappen und das Gewicht des Körpers, Schwanzes und der hinteren Extremität sind bedeutend grösser als in der Serie mit Hypophyse-Implantation. Somit sehen wir, dass das Resultat der Einwirkung auf das Wachstum der Kaulquappen der «eosinophilen Zone» des Hypophysevorderlappens mit der anderen untersuchten Drüsen verschieden ist: bei Implantation der Hypophyse beobachten wir eine bedeutende und dauerhafte Wachstumstimulierung, in den anderenen Fällen—einen kleinen und nur kurzzeitigen Effekt.

Bei kombinierter Einwirkung (Hypophyse+Parathyreoideadrüse) ist der Effekt der Wachstumstimulierung bedeutend grösser: jedoch der Mechanismus des festgestellten Synergismus bleibt bis jetzt noch unklar. Aus den erhaltenen Angaben kann man schliessen, dass die Potenz der Kaulquappengewebe zum Wachstum bei Einwirkung mit der Hypophyse nicht voll erschöpft wird. Die endokrine Regulation des Wachstums bei normaler Entwicklung der Larven trägt wahrscheinlich ein komplexen Charakter.

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ZOOGEOGRAPHY

WARM-WATER *EUPHAUSIIDAE* (*CRUSTACEA*) OF THE MURMAN COAST

By G. V. BOLDOVSKIJ

(Communicated by S. A. Zernov, Member of the Academy, 31. VII. 1937)

On January 22, off Cape Bashenka of Rybachi Peninsula in Shotovski Bay, Barents Sea, a live and entirely uninjured male specimen of *Stylocheiron maximum* H. J. Hansen, 16 mm long*, was caught with a Nansen plankton net of № 3 gauze in a depth of 85—0 metres. The find of this species of *Euphausiidae* off the Murman coast is most interesting from a zoogeographical standpoint. This species had not been recorded from here before.

This is a typical warm-water oceanic species, H. J. Hansen (2) identified it in collections both from the Indian and the Atlantic oceans, in particular among the materials of the «Thor», 1934, west of the Faroe Islands (61°49′ N., 14°11′ W.). G. Illig (1) indicates the following localities of finds of *S. maximum* by the German Deep-Sea Expedition of 1898—1899; Gulf of Guinea, south-west of Ceylon, and off the Chagos Islands.

On the other hand, J. Hjort (3) had failed to meet this form even in the southern part of the Norvegian Sea during his work in the twenties. The oceanic and warm-water character of *S. maximum* is, therefore, unquestionable.

In view of the above, the find of even a single specimen of *S. maximum* off the Murman coast is most interesting as an example of an exceptionally long distance over which a warm-water form was carried northwards.

Another boreal form, *Nematoscelis megalops* G. O. Sars, occurred, according to A. K. Linko's data (4), in the early years of this century in the Barents Sea only as single specimens (5 cases during 7 year investigation) and, moreover, only in the south-western part of that sea, not beyond 72°N. and 35° E. This species was mainly caught in the first half of the year, which, according to A. K. Linko, may be accounted for by the increased pulsations of the North Cape Current carrying this crustacean from the west.

During the period from 1934 to 1937 *N. megalops* was only recorded three times:

1. St. K. 1262, 28. 06, 1934, 71°17′ 5″ N. and 16°00′ E. on the continental shelf in the northern part of the Norwegian Sea in a haul by a Nansen net of № 3 gauze from depth of from 600 to 0 metres, one female 20 mm long, with an attached spermatophore.

* The length was determined in accordance with the method adopted in the plankton laboratories of the Union Research Institute of Marine Fisheries and Oceanography, namely, from the posterior margin of the eye to the origin of the telson.

2. St. H. 3162, 23.07, 1935, 17°09′2″ N. and 24°05′ E., above Inge island, Western Finmarken, in fishing with a net of № 0 gauze for collecting eggs, from depths of from 300 to 0 metres, one female 17 mm long, with an ovary.

3. 18.05, 1937, off the north-eastern extremity of Rybachi Peninsula, in the stomach of a cod, one female, about 15 mm long.

The lack of sufficient data for the first half of the year does not allow us to draw any conclusion as to the greater or lesser frequency of occurrence of *N. megalops* at the present time as compared with former years. The presence, however, in one of the above-recorded females of an ovary with well developed eggs, and in the other of an attached spermatophore permits of the supposition that the reproduction of *N. megalops* occurs in these regions or somewhere not far south of them. This allows us nevertheless to believe that the species in question has lately become more common in these waters than it was thirty years ago. G. Illig (1) states that in the India ocean *N. megalops* mainly occurred at great depth and at temperatures but slightly above 0° (after the data of folding nets). This may, possibly, be rather a stenohaline than a warm-water form, this is, moreover, supported by the fact, that in the part of the Barents sea under discussion salinity is the highest in the first half of the year.

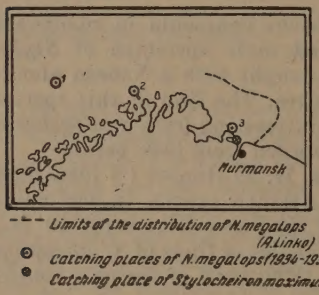

Fig. 1.

Fig. 2.

A certain change has also been observed in recent years in the distribution of the arctic-boreal *Meganyctiphanes norvegica* G. O. Sars. A. K. Linko (4) described the distribution of *M. norvegica* in the Barents Sea as follows: very rare in the Barents Sea, belongs to those truly oceanic elements, which extremely rarely, if ever, approach the coasts; it was caught in the space between 71 and 74°N. and 20 and 41°5′ E., i. e. in a region, where the flow of the North Cape Current can best be traced. And further: «...the time of its appearance was the autumn and winter months»,... «in the summer months, on the contrary, when work is in full sing, *Nyctiphanes* has never been caught». And, lastly: «...it appears to me, that the finds of *Nyctiphanes* in the Barents Sea in autumn and winter may be ascribed to the influence of periodical variations in the head of water in the Gulf Stream».

We have now found *M. norvegica* in regions lying along the main stream of the North Cape Current, eastward up to Novaya Zemlya, in the Novaya Zemlya shallows (72—73° N. and 48—52° E.). Here it was found in stomachs of cod [L. A. Senkevitch and V. A. Broekaja (6)].

In Shotovski Bay, *M. norvegica* occurs all the year round although in different quantities, prevailing in the autumn-winter season (G. V. Boldovskij).

The May materials of 1936 contained males with developing spermatophores, though no females were found with attached spermatophores. This species seems to have acquired some importance as food for herring, for in the autumn of 1936 it constituted the predominant part of the food of many shoals of the herring, which approached the western Murman coasts (G. V. Boldovskij).

M. norvegica has, therefore, in recent years developed from a rare form in the southern part of the Barents Sea into a common form, extending much farther eastwards and, evidently, already wintering here. In any case, it was encountered in all seasons of the year. Moreover, this crustacean obtained a certain importance in the nutrition of edible fish.

Both the extraordinary transportation of *Stylocheiron maximum* so far to the north and the modifications in the biology and distribution of *Meganyctiphanes norvegica* in the southern part of the Barents Sea are easily explained by the rise in the temperature of the Arctic regions as observed during the last fifteen years [W. J. Wiese (5)]; one of the causes of which is an increased head of waters in the Atlantic current. This rise in temperature enables boreal species to penetrate farther notrhwards and in greater quantities and thus to extend their area of distribution. Many papers have lately appeared describing the above phenomenon in respect of different groups of organisms.

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